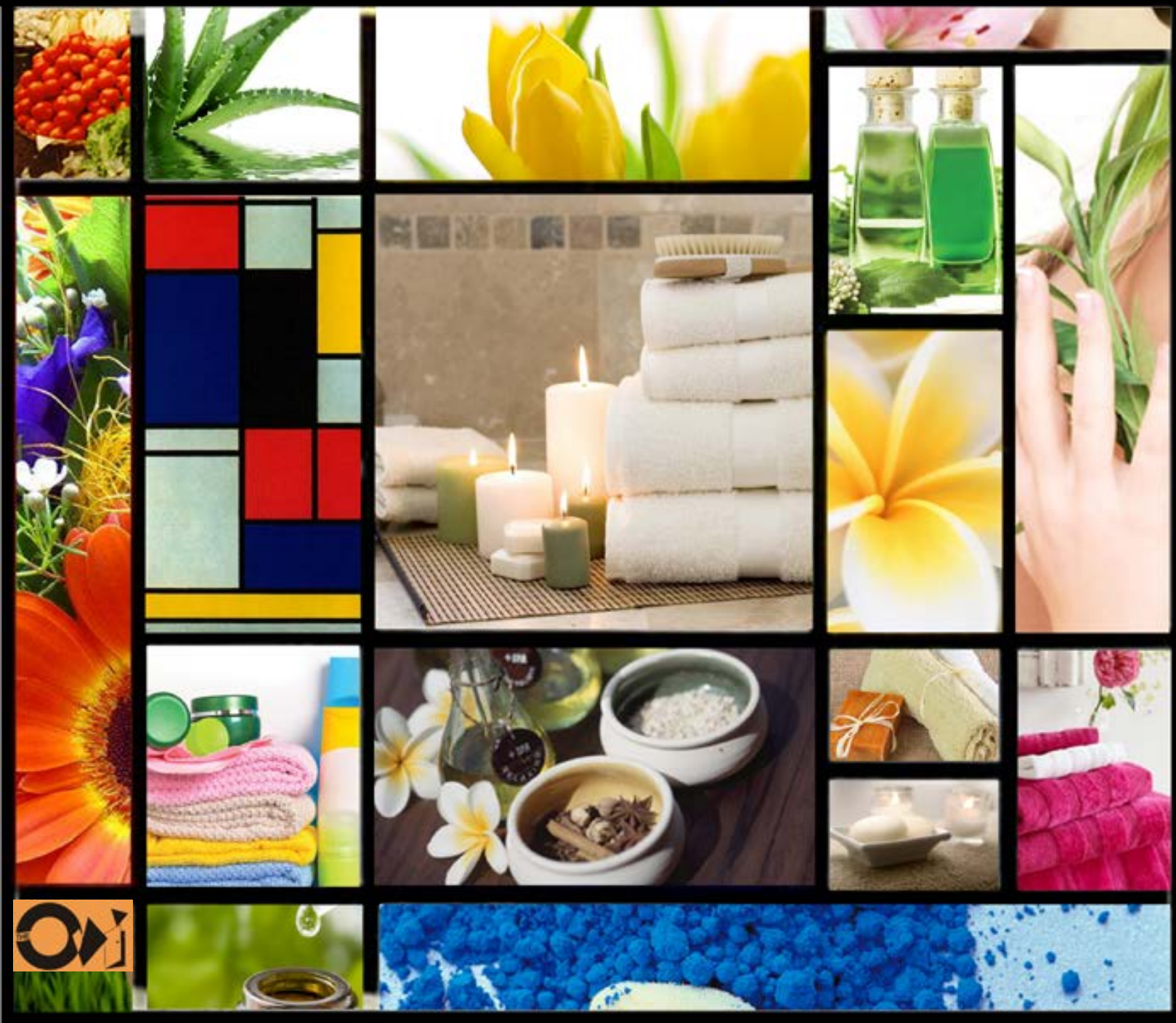
The first line Of personal care Entrepreneurship

Murray Hunter



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Murray Hunter

What Makes a Personal Care Company Successful?

The Organic Production of Essential Oils

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Passion, care and respect

"What Makes a Personal Care Company Successful" and "The Organic production of Essential Oils" is the result of hard work, long research and passion. Actually this is what it takes to succeed both, a successful company and an organic production; passion. Passion to care.

Murray Hunter invites us to share the passion and care for an economy that combines environment and human culture, with respect. Passion, care and respect. Just expand your thoughts beyond a personal care company and organic production of essential oils and she that this is what it takes to live in harmony in an environment that needs your care and respect if you want it to give you the essentials for a graceful life.

This is one of a series of books, Ovi magazine is going to publish with Murray Hunter around environmental and humanitarian friendly economy.

Thanos Kalamidas

Editor of Ovi magazine

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What Makes a Personal Care Company Successful?

Personal care with its artisan beginnings is one of the oldest FMCG industries in existence. The craft began more than 2,000 years ago with skilled artisans producing candles, soaps, and fragrances, very highly valued products by those who could afford them at the time. These collected crafts emerged into a mass consumer industry by the middle of the 20th century. Over the last 25 years the industry has again undergone some massive structural changes. Today the personal care industry could be considered highly concentrated throughout each stage of the supply chain. Yet paradoxically, the industry is now more fragmented and layered than ever before, if one knows where to look. This leads to the question of *"what is needed to make a personal care company successful in today's environment?"*

Personal care items range from products that are important to a person's hygiene, to those that are used purely to enhance self image and develop a persona for others to see. Consequently people tend to use personal care products for reasons other than the primary functions, *i.e., hygiene or colour, etc.* Personal care products have something to do with acceptance, approval, image, and hope. When an underdeveloped economy progresses towards development, one of the first consumer sectors to emerge is the personal care industry. This shows the importance of these products, although many are considered luxury items. In addition the industry is also one of the heaviest users of media advertising.

What constitutes personal care products has become very blurred in recent times. Personal care products take on the characteristics of cosmetics, fragrance, aromatherapy products, pharmaceuticals, and even insecticides. A very rough breakdown of personal care categories are listed in table 1.

Table 1. A breakdown of personal care product categories.

1. Skin Care products
1.1 Bath products
1.2 Skin cleansers
1.3 Skin care products
1.4 Eye care products
1.5 Lip care products
1.6 Nail care products
1.7 Feminine hygiene products
1.8 Foot care products
2. Products with special efficacy
2.1 Sunscreen preparations
2.2 Skin tanning preparations
2.3 Skin beaches
2.4 Insect repellents
2.5 Insect bite lotions
2.6 Deodorants
2.7 Antiperspirants
2.8 Acne care products
2.9 Depilatories
2.10 Shaving cream
2.11 Perfumes
3. Oral care Products
3.1 Oral hygiene products
3.2 Denture cleaners
3.3 Denture adhesives
4. Hair care products
4.1 Shampoo
4.2 Hair care products
4.3 Hair setting products
4.4 Hair care products
4.5 Hair setting products
4.6 Hair waving products
4.7 Temporary and permanent hair colourants

The concept of success

When looking at what makes a successful company, one has to first define what success means. To simply say success is about market-share, sales, market domination, brand recall, profit, and ROI would be too simplistic and fail to recognize that companies and enterprises are as much about their founders, as they are about the products they make, sell, market, and distribute. Success is related to the ambitions, aspirations, and visions of the founder. The founder may just love being part of the industry and delight in producing batches of the finest hand-made soap, or the most beautiful natural perfume. His or her love may be serving a very important customer as a contract manufacturer, and lifestyle is the key to the person's own image of success. Too many *"MBA's"* dismiss the importance of craft and smallness, and are prepared to write off these manufacturers as irrelevant to the market. Nostalgically these artisans are the remains of our spirit and for that reason alone those keeping the craft going are highly successful individuals with *'golden enterprises."*

Thus the scale of the business is important when defining what success is. As mentioned above for many micro-SMEs it's about the craft. Income enables the enterprise to continue providing the founder with the ability to practice his or her craft. This can be seen with many small hobbyists, those eco-tourism farms producing specialized soaps and lotions, and natural perfumers all around the world. Their success is being able to do what they love.

Many family based businesses probably started off as a craft based organization and grew to something much larger over the last couple of generations. Unfortunately, family based businesses are a *dying breed* and have to compete against conglomatized multinationals. To a great degree, family based businesses continued success is about survival and competing against much stronger adversaries.

Then finally there are the multinationals themselves, primarily conglomerates of brands that think in-terms of market dominance, high market-shares, high volumes, distribution matrixes, profit and return on investment. Their success criteria is easily measurable with the standard business performance measurements of the day, with sustainability, ethical compliances, and developing low carbon footprints for their products and firm as added criteria.

Success is actually a very relative concept. It really has more to do with the personal ambitions of a founder or the corporate objectives of a large firm. The rest of this article will look at the areas where a firm must develop competencies and capabilities to be successful according to whatever vision founders and managers may have.

Some of the characteristics of success

The market modus operandi the founder chooses for the firm can be seen through the products placed into the market. This reflects both the opportunities the founder/managers perceive and the identity that the firm wishes to develop and project. This is the living essence or *"soul"* of the company, reflecting the ideas, values and mission of the firm. It starts with the branding, product and sales narrative, right down to the types of packaging, raw materials and service policies that support the firm's operations. The *essence* or *soul* of the company can be seen in *'the way people within the firm do things'.*

Firms have a choice of three basic market types to enter and participate in.

The firm may enter the first level focusing on contract manufacture for other marketing and retailing companies. Within this domain successful contract manufacturers are technically savvy, fully understand what their customers require, and are able to produce products of high quality, very effectively. Success here comes from being able to foresee the needs of others with the competency to fulfill them. To a customer, a supplier that efficiently and effectively services their needs can be considered a source of competitive advantage. Reputation as such will bring many potential customers to your doorstep.

At the second level a firm may manufacture their own branded products for specified markets. This is where the majority of personal care companies exist, within some layer of the mass market in either, discount, supermarket, pharmacy, salon, or branded store markets. Each market layer will have a particular set of idiosyncrasies or culture which must be adopted and adhered to in order to be successful. At this second level firms take a functionalist approach working back from what managers believe consumers want. Product attributes are focused toward providing efficacy with a sense of value for money. This is a very competitive area because usually most companies make the same or similar conclusions about what they believe consumers need.

At the third level, firms and the products exist for some basic reason that becomes the whole persona about what they do. The products exist on some deep passion and belief. The products represent the beliefs and values the founders want to share with their customers. This is very different from the second level where managers try to read what consumers want, a passive reactive approach, rather than proactive creativity required at this level in actually creating new market space.

In this third case products are innovatively constructed with a theme; be it sustainability, ethics, Halal, ethnic, natural, and so on. It is in this area where the rewards are very high for young companies with great ideas, like we have seen with concepts espoused by likes of Aveda, The Body Shop, and Thursday Plantation, among many others for example over the years. One must remember that this is a very high risk strategy. Very few succeed. For every successful company there are hundreds of failures and if you are not totally committed to your cause, consumers will eventually find out and punish you severely.

Capabilities and competencies

A firm must have the **capabilities** to be able to exercise the necessary **market competencies** to be successful in the marketplace.

First of all, a firm must be able to enter and operate within the particular market channels it has selected. This requires developing good working relationships with chain store buyers and wholesalers at salon level. In today's highly concentrated store ownership a good relationship with buyers can offset some of the disadvantages of being a small company within a sea of multinationals. There is also the option of using a sales broker with *'these relationships for hire'.*

What is extremely important is that trading terms are negotiated and utilized correctly. Trading terms has a great bearing on the range of products carried by the retail chains. Within many chains, central listing and addition to the shelf *planogram* may not be enough. Sales staff may be required to make personal visits to familiarize store staff with the new products and in some cases assist in merchandising, particularly through independent stores that are members of branded wholesalers.

Remember the old sales days are long gone. Retail chains will not list and carry lines that compete on price with established brands because it erodes gross profit margins. Retail chains will only list products that have an appealing theme to consumers and will maintain and increase gross profit on the shelf.

Product themes must be supported. They should be supported at two levels, if not three.

This first is what is called *'below the line'* promotion which includes, periodic case deals, discounts, quantity buys, display and shelf promotions at store level. These will usually be negotiated during product listing and again each year during product reviews with the chain buyers. As much as 20-25% of gross sales need to be allocated to *in-store activity.* This should be planned and negotiated well or a lot of funds coming straight off the margin of the product will be very quickly wasted.

The second level is what is called '*above the line'* or media advertising. This will include spending on radio and television, and cinema time, and magazine, and newspaper space. Very rarely would a retail chain list a product without some *'above the line'* media support. Multinationals would spend between 10-25% of their budgets on media.

Launching a new and maintaining an existing product through media is expensive as it requires cash funds to do so, unlike *'below the line'* promotion. One of the challenges for SMEs with very limited funds is being able to create and develop an effective media campaign. Here great creativity is required to find as much free media as possible through radio and TV interview, newspaper and magazine reviews, and of course online blogs and other social media. Don't forget a product advisory website as well. Don't make the mistake to skimp across this area lightly, particularly if you have a new brand to support. The correct promotion brings very positive results which you would not readily be able to achieve sales wise through other methods.

Don't forget social media. Social media is not as yet a primarily means of promotion but very supportive in relaying interviews and reviews that you have got from the mainstream media. Also remember unsatisfied customers through social media have direct access to the rest of your customers like never before. Handle any customer complaints promptly and satisfactorily and maybe an initial customer complaint can turn into something beneficial.

Make and buy – some considerations

The production costs for mass produced high volume products are at the point where it is difficult not to make the decision to source from overseas. Look at the costs of implementing GMP and meeting EPA regulations and sourcing your product offshore looks even more attractive.

Finding a supplier that you can work closely with and develop some mutual loyalty is a challenge. Australia and New Zealand are small markets compared to North America and Europe. Where you may require 1-2 20ft containers per month for a product, US personal care marketing companies may buy as much as 20 times that quantity. So it's not hard to understand you may not get the attention in places like China you feel you deserve. So you have to work hard on getting a contract manufacturer's interest and build up that relationship. As Sun Tzu said an army s only as good as the supply chain it uses, so an excellent supply with a close working relationship will be a great advantage. This in the long run will allow you to focus on sales and marketing, and the big bonus here is that through the savings you make on offshore manufacture, more can be spent on brand development through advertising.

Some low volume, and/or specialized products are best kept *in-house,* especially if there are some unique characteristics to the product. In these cases you need to invest on the engineering side of the product manufacturing process and lower the labour and handling costs as much as possible. You don't need me to tell you what the hourly factory labour rates are.

Create barriers to entry for potential competitors

During my career in the household and personal care industries, for any new product I would try to create a barrier to entry for any potential competitor. Having sole access to any piece of market-space enables one to create a value monopoly, allowing above average profits for a period of time the barrier to entry is maintained. This can be achieved a number of ways. As discussed in the next section, arranging your IP strategy correctly is a powerful barrier to entry, as any configuration is unique, especially if it is difficult to copy. So this may mean a patent on a formulation, process, or form of packaging, the use of raw materials others don't have access to, or especially close relationships throughout the value chain. Developing barriers to entry may involve building your own plant and machinery for specialized products, or producing your own raw materials such as basic soaps, preservatives, enzymes, and perfumes, etc. Being able to downscale expensive production processes for a fraction of the cost that other companies invest is one of the best ways of creating a powerful advantage other competitors.

Any barrier to entry won't last forever, so one must continue to develop new barriers and create new products with new barriers to entry. Don't forget a brand is one of the best barriers

to entry. Barriers to entry are powerful sources of competitive advantage that are not fully utilized in the industry today by smaller firms. This is a very important aspect of success and may enable a small company to compete effectively with a multinational.

Recognize what is your IP and use it well

All businesses involve intellectual property. Intellectual property is much wider than patents, trademarks, research and development, and brands; it's the way you do things, expressed as your total strategy out in the market-place. Understanding this, coordinating your IP and using it to your advantage, is the best way in creating a barrier to entry as we discussed above. Developing intellectual property in this holistic manner is the key to creating the value monopoly for your product and firm that will reap large financial returns.

Intellectual property is a product of competencies. IP can be considered a *box of tools* that can be coordinated in a particular way to fulfill marketing and protection objectives. If done correctly this will be of immense benefit to the firm and create a strong source of competitive advantage. The array of tools that can be used are listed in table 2.

Table 2. Intellectual property tools and there assistance in firm strategy

Category	Purpose	Tools
Recognition	To develop customer recognition and transmit certain desired values of the firm and product to consumers.	Trademarks and certain copyright information
Form	To develop recognizable literary and visual forms that add value and assist in creating an inherent desirability to the form of communication between the firm and consumer	Copyrights, trademarks, and registered designs
Desirability	To enable firms to deliver good products with superior performance to competitors, new features, extended product life, etc. so that products are competitive and desirable.	Patents, registered designs, and proprietary knowledge
Emotional connection	To maximize financial returns for production undertaken by the company, add to product differentiation and develop an emotional connection with consumers.	Brands, trademarks, stories, and narratives.

Stay close to the knitting

Peters and Waterman in their classic book *'In Search of Excellence'* strongly advised that the most successful corporations in the United States during the 1980s were those that *'stick closely to the knit'.* Too many companies that experience some success diversify outside their domains of success and end up with all sorts of problems. For this reason S.C. Johnsons sold off its Agree Shampoo range while it was No. 1 to focus back on its household product range. It is very rare to see a company that is both dominant in personal care and say household products. Successful companies build upon their existing based, rather than build new bases.

It's about the founder just as much as anything else

There is an extremely close correlation between the founder and a successful enterprise. Without a founder there will be no enterprise and the performance of the founder is actually what creates the enterprise. So no surprises, the qualities of the founder are paramount to success. This isn't about personality, or particular traits, it's about a way of thinking.

The most important element is vision. Without vision or a roadmap about what the founder wants to create for the future, it can't be created. Along with this vision must come a high passion and motivation, almost to the extent of being compulsive. Secondly any founder must have a sensitivity and alertness to the industry. He or she must be able to see things that others are unable to see to pick up unique opportunities. Generally because of this many successful new enterprises within the personal care industry are started by those with prior experience within the industry.

Successful founders possess a strategic outlook that enables them to see where they are going and the consequences of any action they take. For example, they will know how their competitors will react and the financial, production, and inventory consequences of any one action. It is this way of thinking that will guide them and this is accompanied by a strong propensity for action. Founders who think too much about the actions they take may be hesitant and fail to take any necessary steps to solve problems when they arise, or miss immediate opportunities that have large long term benefits *(the down side may be reckless decision making).*

A good strategic outlook and propensity to act must be accompanied by the relevant skills and abilities. These may include technical skills in product development, interpersonal skills in sales, and the ability to work with others. A person cannot do everything by themselves so must be able to gather and work with a team. The founder must have the personal creativity necessary to utilize all these skills in the pursuit of his or her objectives and solving of arising problems and challenges on a daily basis.

Finally the founder must have the courage and determination to follow their visions. So many people hold visions about what could be but never act to fulfill them. The absence of any of the above characteristics would severely hinder any chances of success.

Conclusion – *and in the end it's up to you*

Any business is complex and there are indeed so many factors that contribute to any success. Likewise there are so many factors and miscalculations that can lead to failure. These could be basic business mistakes about holding excessive inventory or strategic issues like selecting market categories that don't have enough potential customers to make an enterprise viable – a trap many SMEs fall into.

A successful personal care company is about products, channels, networks, image, narrative, promotion, competitors, and intrinsically understanding the nature of the consumer you strive to serve. One must think in a holistic way, but also be focused upon all the detail and create and develop the right products, develop the right image and channels, and answer four important questions satisfactorily for maximum success;

1. What is the central theme of your product?

2. Are there enough customers?

3. What channels do you need to go through to reach your potential customer? And

4. How much competition will you face?

The human race has sent men to the moon, cured many diseases, mapped the human genome and descended to the deepest depths of the world's oceans, but nobody can be really too sure about the reasons why one business is successful and another business is a complete failure. What really makes a shampoo, fragrance, or spa a success? People who say they know are really guessing. We can only really tell what the next big thing is when it becomes the next big thing.

However we know that the reason for a business success is based on very tight, but not necessarily apparent factors, of which the successful entrepreneur may not even understand. *Who can tell exactly why Lady Gaga is a success?* You can give me a number of reasons but can't tell me which ones are most important. If you could predict the future hits with any certainty – no doubt your already a multi-billionaire and not reading this.

Business success is about the future and there is no way to predict the future accurately. So any new business is developed along the lines of trying something to see if it works, and then keep doing that thing if it actually worked. Success doesn't come from beautiful business plans, it comes from experimenting until – BINGO!!! You've got it. Then you have your own magic formula that works only for you and your situation.

There is a unique and hidden success formula waiting for you to find in your business. You may stumble upon it very quickly or never find it at all. There are plenty of business books out there with the 10 rules, habits, or points that claim to lead to success. The factors mentioned may exist but not necessarily be the true reasons behind your success. Having a lucky charm may have just as much influence over the matter.

The Organic Production of Essential Oils

Organic farming involves crop cultivation to produce uncontaminated products free of pesticides, herbicides and heavy metals according to ecological principals while maintaining sustainability. There is remarkable growth for organic products today with organic orientated supply chains developing throughout mainstream markets. Organic farming is considered by a number of people to be a viable alternative to conventional farming. A great number of essential oils are produced organically around the world although not certified as such. This chapter looks at the place of organic farming within the continuum of farming systems and discusses the basic principals of organic farming which include crop rotation, cover crops and green manures, animal manures, intercropping, composting, mulching, crop diversity, natural fertilizers, minerals and supplements, insect and disease control, weed control, tillage and farmscaping. The chapter concludes with a look at the planning and certification process and the extent of organic farming in the Asia-Pacific Region today.

Introduction

Until the 'green revolution' took place in the late 1940s agriculture relied primarily on traditional methods of production, based on preventative measures and local inputs. Through technological advances during the Second World War in many fields including agriculture, farm productivity improved dramatically. This was achieved through chemical based fertilizers, pesticides and herbicides, ironically 'spin-offs' from chemical warfare programs. In addition, a number of labour saving and automation inventions and innovations, such as tractor plough arrays and automatic harvesters enabled the development of extensive farming on much larger scales than ever before.

The *'green revolution'* dramatically increased farm productivity and it took some time for people to become aware of a number of undesirable consequences. Doubts eventually developed about the long term viability and sustainability of these new agricultural practices [1].

These doubts fell in two broad areas;

Firstly, conventional agricultural has degraded natural resources like rivers, lakes and underground water tables, through chemical residuals from fertilizers, pesticides and herbicides leaking from the system. Mono-cropping and constant tillage had worn down soil nutrients contributing to the erosion and disappearance of humus and tops soils. Conventional agriculture was seen as very disruptive on eco-systems, contributing to the demise of biodiversity within farming areas. These undesirable effects from conventional agriculture contributed to the general degradation of the environment.

The second doubt arose of the need to utilize public funds to subsidise non-sustainable practices. Farm inputs like chemical fertilizers, pesticides and herbicides are usually manufactured long distances away and need to be transported to farms. These chemical inputs are manufactured using non-renewable resources and energies leading to CO2 emissions, thus having negative effects to both the economy and environment [2].

From the scientific point of view, organic farming practices are seen by some as a solution to many problems. Eliminating the use of pesticide assists in opening up degraded eco-systems for re-diversification [3]. Organic farming can assist in reclaiming, rehabilitating and restoring biological diversity [4]. Organic farming practices generally reduce nutrient leaching of the soil [5], and arrest the degradation caused by conventional farming, hence the term given to organic farming by some; *regenerative agriculture*. Organic farming philosophy sees agriculture as part of a complex eco-system, which if approached with the correct practices to manage functional relationships, would increase productivity. Organic agriculture is seen as a way to reduce dependence on chemicals [6] through practicing agriculture in a coordinated way within existing eco-system cycles.

From the consumer perspective, organic foods have been associated with health, safety, social responsibility, ethical issues [7] and cleanliness. Many consumers believe that organic products are superior in quality to conventional products, safe and socially responsible [8]. This is certainly the view of many aromatherapists, natural herbalists and pharmacists [9]. This has been reinforced by food scares and the debate over *'genetically modified'* foods. Major retailers now promote organic lines and multinational processed food manufacturers are launching organic products which contribute to increasing consumer attention to the sector and promote growth in the World market [10]. In 2008, the worldwide market for organic products was approximately USD 36.5 Billion, including the fast growing organic cosmetics market (see Figure 10.1). The general organic market is growing approximately 10-15% per annum, while the organic cosmetic market is said to be growing somewhere between 20-30% per annum [11]. However, even with this growth, only 1-2% of total agricultural land is under organic cultivation today [12].

The organic cosmetics segment is still considered a niche market. Although still very small compared to the conventional market, a number of corporate strategic moves have taken place in recent times to indicate that this market niche will continue to dramatically grow in size over the next few years. L'Oreal, often cited as the World's largest cosmetic company, purchased The Body Shop in 2006 [13]. Colgate-Palmolive and Clorox have also made large purchases of companies producing "green" and "organic" products, the following year. A recent report states that both Unilever and S.C. Johnsons are also looking for strategic purchases in this area [14].

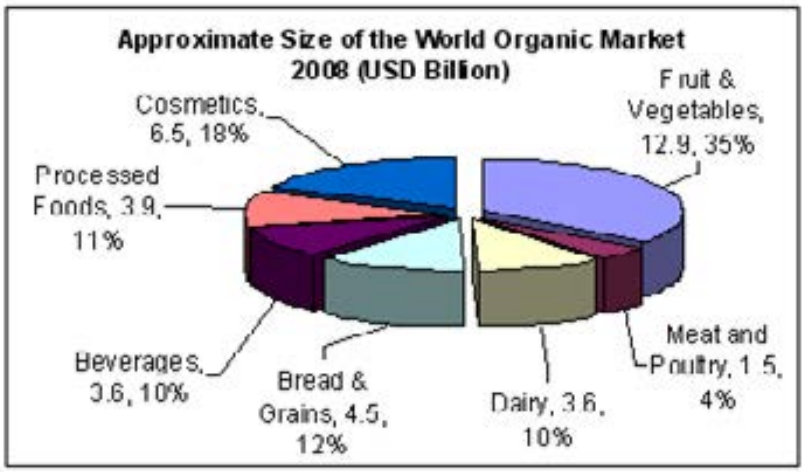

Figure 10.1. Approximate Worldwide Market for Organic Products 2008

Aiding in the development of the 'green' and 'organic' markets is the growth of the ethical market. The ethical market began to emerge with changing social thought during the 1960s, triggered by a number of watershed opinions published in the 1960s and 1970s. The publishing of the Rachel Carson's book *Silent Spring*, criticized the chemical industry of spreading disinformation about the effects of pesticides [15]. In the 1970s, *The Limits to Growth* questioned the Earth's ability to feed itself with rapid population growth and warned of grave environmental consequences [16]. E.F. Schumacher in 1974 published *Small is Beautiful* which radically questioned the way we organize ourselves, criticising economic growth without personal fulfillment and quality of life [17]. Schumacher was also the president of the UK Soil Association, where the issues of social responsibility and fulfillment found their way into organic farming sustainability philosophies. Consequently, these issues have become somewhat fused together, where the *Fairtrade* movement has become very closely associated with the organic movement [18]. Like organic cosmetics, ethical cosmetics are still only a niche market. However, there were more than 2,260 product launches in Europe alone during 2007, five times as many in the previous year [19].

Organic essential oils include, a) those produced by traditional means which are not usually certified, b) specially organically cultivated and usually certified, and, c) those collected from the wild, existing in a natural eco-system and also not certified. Examples of essential oils produced by traditional means would normally include patchouli, citronella, and vetiver oils in Indonesia and Vietnam. These oils although produced organically, are usually not certified as such, and carry no price premium in the market. Specially cultivated organic essential oils would include those like lavender and other herbs cultivated on hobby and agro-tourism farms, usually for small local markets, such as tourists visiting the farm. By definition, essential oils produced from materials collected from the wild are also organic, as they have grown in an untouched natural eco-system, although they may not be certified organic.

Even with all the attention that has been given to organics and fair-trade, the actual production of organic essential oils is very low in terms of volume. In terms of value, organic essential oil production is presently little more than 2-3% of total production. This excludes essential oils that have been wild harvested or produced by traditional methods. Table 10.1. lists some organically produced essential oils and their production locations, offered to the market as *organic oils* today.

Table 10.1. Some Organic Essential Oils and Their Production Locations Offered to the Market Today.

Oil	Scientific Name	Location	Cultivated/Wild Harvested
Allspice Berry Oil	*Pimenta officinallis*	West Indies	Wild Harvested
Angelica Root Oil	*Angelica archangelica*	France, Canada, Hungary	Cultivated
Angelica Seed Oil	*Angelica archangelica*	France	Cultivated
Anise Seed Oil	*Pimpinella anisum*	France, Spain	Cultivated
Artemisia Oil	*Artemisia absinthium*	China, Morocco	Wild Harvested
Bay Oil	*Pimenta racemosa*	West Indies	Wild Harvested
Basil Oil	*Ocimum basililcum*	Comoros Islands, Madagascar, United States	Cultivated
Bergamot Oil	*Citrus bergamia*	Italy	Cultivated
Cajuput Oil	*Melaleuca cajuputii*	Vietnam	Cultivated
Camphor Oil	*Cinnamomum camphora*	Madagascar	Cultivated
Caraway Oil	*Carum carvi*	India	Cultivated
Cardamom Seed Oil	*Elattaria cardamomum*	Guatemala, Hungary	Cultivated
Carrot Seed Oil	*Daucus carota*	France, Hungary	Wild Harvested
Catnip Oil	*Nepata cataria*	France	Cultivated
Cedarwood Oil, Atlas	*Cedrus atlantica*	United States	Cultivated
Cedarwood, Virginia	*Juniperus virginiana*	United States	Wild Harvested
Chamomile Oil	*Matricaria chamomilla*	Morocco, France, United Kingdom	Cultivated
Cinnamon Bark Oil	*Cinnamomum zeylanicum*	Sri Lanka	Cultivated
Cinnamon Leaf Oil	*Cinnamomum zeylanicum*	Sri Lanka	Cultivated
Citronella Oil	*Cymbopogon nardus*	Brazil, Vietnam	Cultivated
Clary Sage Oil	*Salvia sclarea*	France, United States	Cultivated

Clove Bud Oil	*Eugenia caryopyllata*	Comoros Islands, Indonesia, Madagascar, Tanzania	Cultivated
Coriander Seed Oil	*Coriandrum sativum*	Egypt, France, Hungary, Russia	Cultivated
Cumin Oil	*Cumimum cymimum*	India	Cultivated
Cypress Oil	*Cypressus sempervirens*	France	Wild Harvested
Dill Seed Oil	*Anethum graveolens*	Bulgaria, France, United States	Cultivated
Eucalyptus Oil	*Eucalyptus globules/ radiata*	Australia, Portugal	Cultivated/Wild Harvested
Sweet Fennel Oil	*Foeniculum vulgae*	Australia, France, Italy	Cultivated
Galangal Oil	*Alpinia galangal, officinalis*	Indonesia, Thailand	Wild Harvested
Geranium Oil	*Pelargonium graveolens*	China, Egypt, Kenya, Malawi, South Africa, Zambia	Cultivated
Ginger Oil	*Zingiber officinale*	China, Indonesia	Cultivated
Grapefruit Oil	*Citrus paradisi*	Argentina	Cultivated
Juniper Berry Oil	*Juniperus communis*	France, Nepal	Cultivated
Lavener Oil	*Lavendula angustifolia*	Australia, France, South Africa, Spain	Cultivated
Lemon Oil	*Citrus Limon*	Argentina, Italy, United States	Cultivated
Lemongrass Oil	*Cymbopogon citratus*	India, Madagascar, Malawi, Nepal, Sri Lanka, Tanzania, Zambia	Cultivated
Lime Oil	*Citrus aurantium*	Mexico	Cultivated
Litsea cubeba Oil	*Litsea cubeba*	China	Wild Harvested
Lovage	*Levisticum officinalis*	France	Cultivated
Mandarin	*Citrus reticulata*	Italy	Cultivated
Manuka Oil	*Leptospermum scoparium*	New Zealand	Wild Harvested
Marjoram Oil	*Marjorana hortensis*	France, Hungary, Spain	Cultivated
Neroli Oil	*Citrus aurentium*	Comoros islands, France	Cultivated
Niaouli Oil	*Melaleuca quinquinervia*	Australia, Madagascar	Cultivated
Nutmeg Oil	*Myristica fragrans*	India	Cultivated
Oregano Oil	*Oreganum vulgare*	France, Hungary, United States	Cultivated
Palmarosa Oil	*Cymbopogon martini*	India, Madagascar, Nepal	Cultivated
Parsley Seed Oil	*Petroselinum sativum*	Australia, France, Hungary	Cultivated
Patchouli Oil	*Pogostemon cablin*	Indonesia, Madagascar	Cultivated
Pennyroyal Oil	*Mentha Pulegium*	Morocco	Cultivated
Pepper Oil	*Piper Nigrum*	India, Madagascar, Sri Lanka	Cultivated
Peppermint Oil	*Mentha piperita*	France, India, United States	Cultivated
Petitgrain Oil	*Citrus aurantium*	Egypt, Paraguay	Cultivated
Rose Oil	*Rosa damascena*	Bulgaria, Iran	Cultivated
Rosemary Oil	*Rosmarinus officinalis*	France, Malawi, Morocco, South Africa, Spain, Tunisia, Zambia	Cultivated
Rosewood Oil	*Aniba roseaodora*	Brazil	Wild Harvested
Spearmint Oil	*Mentha spicata*	United States	Cultivated
Spruce Oil	*Tsuga Canadensis*	Canada	Wild Harvested

Tarragon Oil	*Artemisia dracunculus*	South America	Cultivated
Tea Tree Oil	*Melaleuca alternifolia*	Australia	Cultivated/Wild Harvested
Thyme Oil	*Thymus vulgaris*	France	Cultivated
Vanilla Extract	*Vanilla plantifolia*	Madagascar	Cultivated
Verbena Oil	*Lippia citriodora*	France, India	Cultivated
Vetivert Oil	*Vetiveria zizanoides*	Haiti, Madagascar	Cultivated
Ylang Ylang Oil	*Cananga odorata*	Comoro Islands, Madagascar	Cultivated

Only essential oils extracted through physical processes can be correctly called organic. Concretes, absolutes and oleo resins that have utilized a hydrocarbon solvent (except organically produced ethanol) cannot be called organic. Most of these materials would contain traces of solvent from the extraction process. However CO2 extraction (an inert gas), which doesn't leave any residual traces in the end product is an allowable method of extraction for organic oils, along with steam distillation.

The growth of organic essential oil production has been slower than other organic segments. This may be the case for a number of reasons;

1. The price difference between organic and conventional essential oils is much wider than other organic categories. Organic essential oil prices are usually 3 or 4 times the conventional price. This restricts the purchase of organic essential oils to only the most discerning consumers, usually for aromatherapy purposes. These high prices discourage greater demand for organic products [20].

2. On the supply side, high prices are perpetuated by the lack of reliable producers.

3. Consumers tend to see essential oils as 'natural' products, *and 'more or less organic anyway'*. Thus there is little incentive to producers to undergo the organic certification process, which is both time consuming and expensive [21].

4. There are organic cosmetic certification abnormalities, where synthetic materials can still be used as fragrances in organic cosmetics. This inhibits the growth of organic essential oil production, and

5. Current EU organic product certifications that allow non-organic 'natural' materials in a product, as long as they are under 5% of the total formula.

Should natural material requirements become more stringent in the future, demand for organic essential oils will dramatically increase.

Organic products are usually distinguished from conventionally produced products by the way in which the product is produced rather than the physical properties and attributes of the product. This does not guarantee organic products are superior in quality to products produced by conventional means. While some producers take great pride in organic production and some consumers are interested in ecologically sustainable production systems, the majority are interested in the product itself and what it can offer relative to competitors [22].

There is also great consumer confusion over the meanings and significance of terms, logos, labels, certifications, trademarks, certainty of supply, quality and price [23]. Labeling laws differ between countries. There is little, if any empirical evidence of the environmental and health advantages of organic agriculture. Chemically, there is no difference between organic and conventionally produced essential oils. However many claims are made that organic oils are superior. The only physical advantages are that an organic essential oil will not contain any pesticide residuals and people involved in the production will not be exposed to any pesticides [24].

Before exploring the concepts and principals of organic production further, it is important to briefly mention the some of the issues that bring confusion to this topic. Most people believe that organic products are produced without artificial fertilizers and pesticides and have been produced with a high degree of environmental awareness [25]. Many consumers have the image that organic farming is monolithic in concept and practices, and is a guarantee of sustainability.

There are a large number of farming concepts each with different production systems developed from various origins and philosophies in existence. These systems range from wild collection and harvesting with zero crop intervention to high input chemical intensive *(i.e., fertigation)*, which represent techniques that are highly interventional in the farming process as shown in Figure 10.2 [26] and Table 10.2.

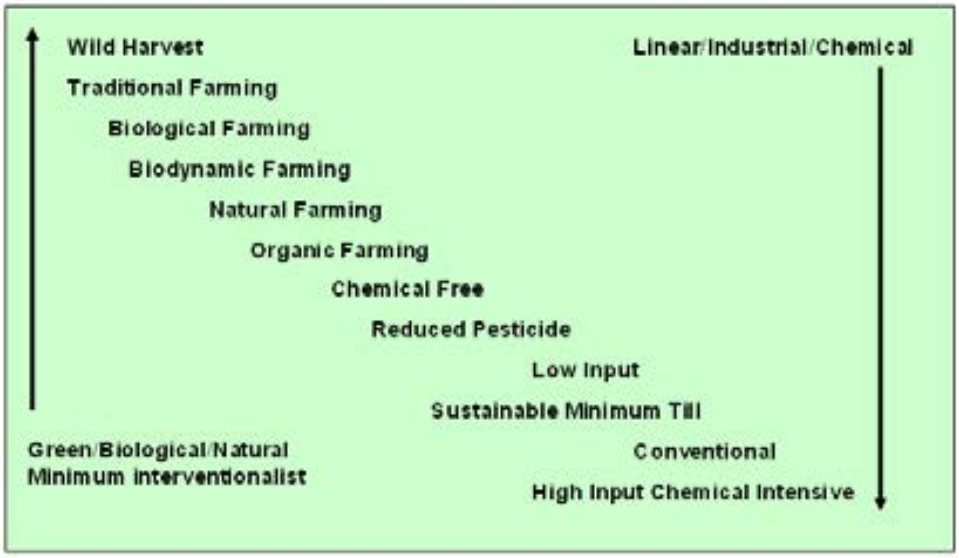

Figure 10.2. The Continuum of Farming Techniques

Table 10.2. Definitions of the Spectrum of Farming Systems

Farming Paradigm	Brief Explanation
Wild Harvest	Hunting and gathering of foods still remains an important activity in semi-arid, humid and tropical areas, and mountainous areas around the world. Wild collection areas are usually associated with undisturbed systems of the ecological diversity and thus receive no inputs from the gatherers. For various reasons *(i.e., very large trees with long gestation period for harvesting)* many wild plants are not domesticated and thus wild harvesting is required. Over exploitation of many species has lead to endangerment of these species.
Traditional Farming	The term Traditional agriculture is usually associated with primitive agricultural systems or pre-industrial peasant agriculture [27]. Traditional farming methods developed over long periods of time through trial and error according to the requirements of site specific soil, climate, weather and social conditions. This knowledge slowly evolved and improved as new information was discovered and passed down from one generation to another. Much of this information has never been formally recorded. As indigenous communities were usually isolated, only locally available inputs could be utilized, which generally made for sustainable agriculture practices. Traditional systems usually cultivated indigenous crops which have partly been replaced by introduced crops over the last few decades. This has led to the disappearance of a number of indigenous plants like aromatic rice and herbs.

Biological Farming	Biological farming is based on balancing the general microbial activity of the soil on a farm. When microbial activity is balanced, livestock, plant nutrition will be healthy; insects, diseases and weeds will be in harmony with the farm. Excessive pests, diseases and/or weeds are seen as symptoms of a larger problem with microbial activity and balance. A number of diagnostic instruments are utilized to measure various soil parameters. A range of microbial nutrients are used to assist the soil maintain its microbial balance.
Biodynamic Farming	Biodynamic farming evolved from the doctrines and philosophies of the Austrian anthropologist Rudolf Steiner in the 1920s. Biodynamic farming aims to produce a closed nutrient cycle that is regenerative, utilizing the integration of animals, carefully chosen crop planting times and an awareness of life processes in nature in a holistic manner. Eight specific preparations are used to maintain balance on the farm. These include cow manure, silica and herbal composts to treat specific soil imbalances.
Nature Farming	Nature farming (mostly practiced as Kyusei Nature Farming) was developed out of a philosophy based on both nature and humanity by Mokichi Okada in Japan during the 1930s. Although many principals are similar to organic farming, the guiding philosophy specifies pre-treatment of organic materials with EM (effective micro-organisms) to sanitize, purify and convert for farm use. This and most other principals have both a spiritual and practical basis [28].
Organic Farming	Organic farming is a production system which excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. Organic farming systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes, mechanical cultivation, mineral bearing rocks, and biological pest control to maintain soil fertility, to supply nutrients, and to control insects, weeds, and other pests [29]. Some modern definitions include clauses relating to social justice and the environment. These methods are tailored to site specific conditions.
Chemical Free Farming	A very similar method to organic farming, except chemical free farming does not use any chemical pesticides or insecticides on crops, in contrast to organic farming which allows a number of products to be used. Often referred to the *"third world"* version of organic farming, where farmers cannot afford chemicals [30].
Reduced Pesticide Farming	Reduced pesticide farming developed as a result in the United States following concerns about health, environment, food security and operating costs [31]. The driver of these programs was primarily the high direct operational costs of using industrial pesticides and their affect on yields [32]. Some form of Integrated Pest Management (IPM) is utilized as a way to optimize and manage pesticide usage [33].

Low Input Farming	Low input farming is based on reducing chemical fertilizers, insecticides and herbicides to a minimum usage in farm production. Biological farm practices are utilized in their place. These practices are usually developed as cost saving measures and to make minimum impact on the environment.
Sustainable Minimum Till Farming	Sustainable minimum tillage farming is a conservation farming method, utilized in semi arid and drought effected areas to reduce the effects of soil erosion and soil structural decline through maintaining organic matter in the soil to promote the growth of soil organisms [34]. Minimum tillage assists in conserving soil moisture. Sustainable minimum tillage can encompass reduced tillage, direct drilling or zero tillage.
Conventional Farming	Conventional agriculture is an industrialized agricultural system characterized by mechanization, mono-cropping, and the use of synthetic inputs like chemical fertilizers, pesticides and herbicides. Emphasis is on maximizing yields, productivity and hence financial profitability through linear thinking and operational approaches. This is a relatively recent form of agriculture enabled by the 'green revolution' after World War II.
High Input Chemical Intensive Farming	High input chemical intensive farming is an intensive farming system utilizing high levels of fertilizers, growth regulators, pesticides and herbicides to obtain the highest possible yields and productivity. These systems are usually accompanied with high rates of mechanization to save labour. These systems usually involve factory farming, aeroponics, fertigation, hydroponics systems, rice paddy, aquaculture, some urban agriculture, and vertical agriculture, etc.

There is little consensus as to the precise meaning of sustainability in agriculture [35]. One view by Ikerd, which summarizes much of the current thinking is that the general elements of any system of practice must be capable of maintaining usefulness and productivity to society, be environmentally resource wise, socially supportive and economically viable and competitive [36]. Organic farming practices are only part of sustainable agriculture. It is no guarantee of sustainability.

It is uncertain what practices actually bring about sustainability due to the complex nature of interrelationships between agricultural production and the environment [37]. Poor environmental practices like leaching of nitrates from the soil and diminishing nutrient levels in the soil could still occur during organic agriculture [38]. Developing an organic system of practices will take some time to create through research, trial, error and transition, with some degree of uniqueness in each farm site. Achieving sustainability is reliant on the farmers understanding and knowledge of the cause and effect relationships and linkages between

various parts of the farm and the surrounding eco-system [39]. Acquiring this knowledge on a site specific basis can take a number of years of trial and error.

Another issue to consider, increasing the difficulty of developing sustainability is the declining capacity of land due to salinity, rising water tables, soil acidification, nutrient and soil structure depletion, erosion, and loss of biodiversity. Some estimates put this decline at 10% of useful land, per annum [40].

Sustainability is an overall objective rather than a mandatory fulfillment of organic farming. Sustainability is very much a site specific concept, multi-faceted and thus complex; requiring not just attention to environmental issues, but economic and social as well. Organic certification requirements reflect this and are not uniform, differing from body to body around the World. Thus organic standards are diverse.

Organic agriculture originally developed from knowledge fused together from traditional and indigenous systems, enhanced with insights from modern agro-ecological ideas [41]. These concepts and practices were further influenced by a number of different schools of thought, which have tended to blend together over time, which is reflected in their specific practices. The methods employed will also greatly differ according to climate, geography and particular site requirements. Site specific solutions may be heavily influenced by traditional farming methods used in the farmer's particular region. Organic farming practices on a specific farm will most likely employ a *uniquely site specific* approach developed through personal experience and knowledge gained by the farmer over many years of working a particular piece of land.

Basic Organic Farming Concepts and Practices

Organic agriculture can be described as a method of farming a selected piece of land within it's biological and ecological processes and cycles, with focus on maintaining a closed and renewable system of inputs, minimizing waste, maximizing recycling, and reducing reliance on external farm inputs. With the need to maintain a closed biological and ecological system, farming methods must enhance and manipulate existing natural processes. Farm management must therefore be biologically cyclic and place heavy emphasis on creating a sustainable local eco-system and soil nutrient system. Organic farming should be undertaken with an aim where practices should not deplete resources, be non-polluting to the environment and practiced within accepted social values. For these reasons, organic farm management is very different from conventional farm management (see Table 10.3.).

Table 10.3. Comparison of Organic and Conventional Farming Models [42]

Organic Farming Model	Conventional Farming Model
Requires knowledge development	Energy Intensive (both direct and indirect)
Cyclical Processes	Linear Process
Farm as an Ecosystem	Farm as a Factory
Enterprise Integration	Enterprise Separation
Many Enterprises (product & Venture diversity)	Single Enterprise

Diversity of Plants and Animals	Monoculture
Higher-Value Products	Low Value Products
Multiple Use Equipment	Single Use Equipment
Active Marketing	Passive Marketing

Organic agriculture requires a holistic management system that utilizes practices to benefit from biological cycles rather than intervene through chemical and other off-farm inputs. An organic system according to the Codex standards should;

"a) enhance biological diversity within the whole system;

b) increase soil biological activity;

c) maintain long-term soil fertility;

d) recycle wastes of plant and animal origin in order to return nutrients to the land, thus minimizing the use of non-renewable resources;

e) rely on renewable resources in locally organized agricultural systems;

f) promote the healthy use of soil, water and air as well as minimize all forms of pollution thereto that may result from agricultural practices;

g) handle agricultural products with emphasis on careful processing methods in order to maintain the organic integrity and vital qualities of the product at all stages;

h) become established on any existing farm through a period of conversion, the appropriate length of which is determined by site specific factors such as the history of the land, and the type of crops and livestock to be produced" [43].

Achieving sustainability within the context of organic agriculture at any site will require some time to learn and experiment with ideas and concepts. Most often these ideas and concepts will need enhancement and modification during experimentation to achieve desired outcomes. Farming concept experiments must be coordinated with cycle times, so the learning period can

often take some years to acquire sufficient knowledge to develop proven sustainable practices for any specific farm site.

As mentioned, organic farming had its origins in traditional and indigenous farming systems. Since traditional farming times, many contributions by organic farming pioneers have helped to develop a set of organic principals. Sir Albert Howard, while working on an agricultural research station in India during the early 1920s emulated many concepts from the indigenous farmers to develop the *Indore Process* of composting [44]. Howard's ideas about soil management [45] were enhanced by J. J. Rodale in the United States who added crop rotation and mulching concepts [46]. Steiner's work on biodynamic farming in the 1920s and Okada's work in the 1930s further enhanced the concepts of what was first called organic agriculture in 1940 by Northbourne, who presented the concept in an integrated manner in his book *Look of the Land* [47].

Others who made contributions include Lady Eva Balfour who compared organic and conventional farming in farming trials in the UK in the 1940s. Hans and Maria Mueller in Switzerland developed pioneering techniques during the 1950s. Hans-Peter Rusch in his book *Bodenfruchtbarkeit,* was one of the first to make strong scientific links between soil fertility and microbiology of the soil [48], where all schools of organic thought agree upon. The formation of the International Federation of Organic Movements (IFOAM) in 1972 and the development of the Codex Alimentarius organic farming principals have contributed to the development of a farming concept where practices can be assessed for compliance and validated with a certification certificate. These principals and corresponding practices are shown in Figure 10.3. which sets out the objectives and operational principals of organic farming.

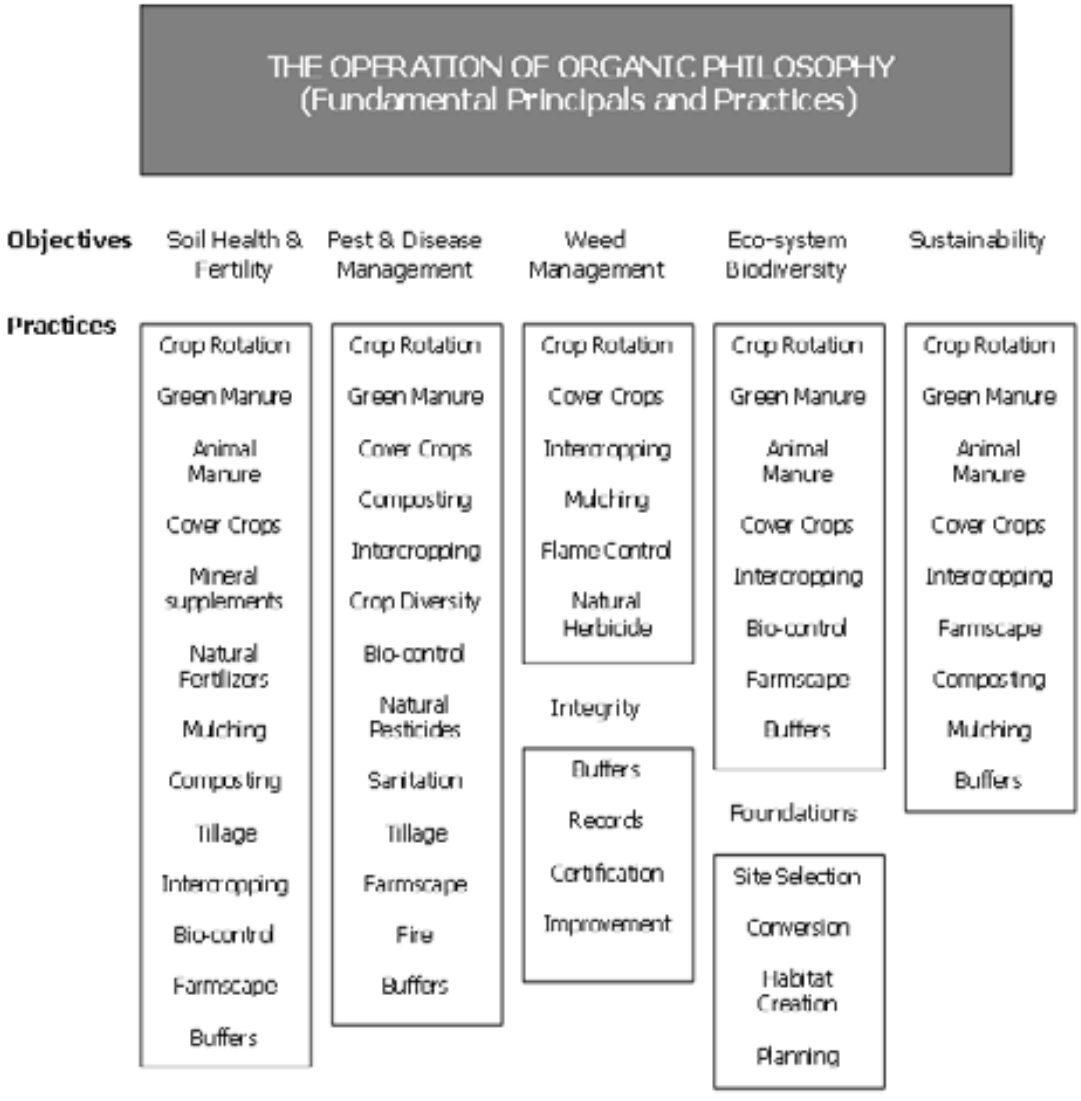

Figure 10.3. The Operation of Organic Philosophy: Fundamental Principals and Practices of Organic Farming

Crop Rotation

Crop rotation is a method where crops are planted within the same field on a rotational basis over a certain period of time. Selected crops are usually sequenced according to their effect on the soil, the existing state of the soil, climate and precipitation to replenish soil nitrogen and other nutrients, reinvigorate soil structure, and break up pest and weed cycles in a field. Crop rotation is important within an organic farming system for soil health and fertility, pest and disease management *(both airborne and in the soil)*, weed management, eco-system diversity and sustainability. Crop rotation systems were first practiced in Roman times throughout Europe and the Middle East. It was also practiced on the African and Asian Continents. The practice all but disappeared in the West with the advent of the *'green revolution',* where artificial fertilizers and soil pH adjustment chemicals where used to allow crop specialization *(mono-cropping)* all year round.

Utilising crop rotation to improve soil fertility can be skillfully undertaken with a selection of legumes and other crops to assist nitrogen and other nutrient replenishment in the soil. This is a great advantage with crops that exhaust nitrogen in the soil and are dependent on specific levels of nitrogen for yield optimization [49] like peppermint [50]. Crop rotation is an advantageous practice in bringing up pre-planting levels of nitrates. Similarly, patchouli rapidly exhausts nitrates from the soil and crop rotation is often practiced [51].

Crop rotation is effective for perennial herb crops such as chamomile, calendula and coriander, but not possible for annual and permanent aromatic tree crops like lemon myrtle and tea tree. For annual and permanent crops, cover crops and green manures can be utilized.

Cover Crops and Green Manures

Cover crops are annual, biannual or perennial plants grown in a pasture either as a mono or complementary crop to assist in the production of the primary crop. Cover crops include green manures which are crops usually ploughed into the field during flowering, living mulches to assist in weed suppression, catch crops to prevent soil erosion after harvesting of the primary crop or a forage crop for incorporation into the soil [52]. Cover crops can be legumes, cereals or grasses depending upon their intended field application. Cover crops are utilized in organic

agriculture for the following purposes;

- To prevent soil erosion

One of the most important functions of a cover crop is to prevent soil erosion and preserve field top soils. Correctly chosen cover crops can greatly lesson the impact of rainfall on the soil and slow down the rate of natural water channeling, which carries top soil away with it. This allows more time for the soil to soak in the rain and reduces the amount of water that drains off the field.

- As a source of soil nitrogen

Organic farmers utilize green manures from legume crops *(Fabaceae or pea family)* which contain nitrogen fixing symbiotic bacteria inside nodules of the root systems that can convert atmospheric nitrogen into nitrates that can remain fixed in the soil. Killed off leguminous cover crop can contribute between 10 to 50Kg of nitrogen per Hectare depending on the particular crop and cultivation conditions [53]. This is usually done as a forage crop after a harvest to replenish the soil nitrates as part of a crop rotation plan. In temperate climates lentils, alfalfa, acacias, cowpeas, soybeans and various types of clover are examples of commonly utilized as cover crops for this purpose. *Mucuna pruriens* [54]*, Canavalia ensifrmis* [55] and *Crotalaria ochroleuca* [56] are all used in semi arid regions and *Calapogonium mucunoides, Centrosema pubescens, Indigofera tintoria, Mucuna cochinchinensis, Vigna radiate* and *Pueraria javanica* are widely used in tropical countries like Malaysia [57].

- To improve soil fertility with organic matter

Cover crops and green manures increase the percentage of organic matter in the soil. This has a number of benefits in assisting in the release of necessary nutrients and elements beneficial for plant growth. Besides nitrogen, green manures also release phosphorous (P),

potassium (K), calcium (Ca), magnesium (Mg), sulfur (S) and other nutrients into the soil upon decomposition. The breakdown of green manure in the soil promotes the growth of micro-organisms which assist in releasing the above elements into the soil. Additionally, the breakdown of green manure also produces organic (carbonic) acids which help to breakdown insoluble minerals and phosphates from rocks and rock based soils [58]. Through extra organic matter, soil structure improves its capacity to hold moisture and nutrients. The root systems of some cover crops can loosen and aerate compacted soil with similar effects to deep tillage [59].

- Weed Control

Cover crops have become a very popular method of weed control, especially in tropical climates over recent years. Cover crops and green manures can suppress weed growth through a number of methods. Most non-legume green manure crops are primarily utilized for weed control purposes. They suppress the ability of weeds to establish themselves through providing competition. When the cover crop is mowed or cut and left on the ground it forms fairly impenetrable mat structured mulch that protects the covered area through hindering the ability of weeds to germinate by cutting out light [60] and smother any existing weeds [61]. When these matted mulches are tilled into the soil, they add organic matter to the soil. Some cover crops also prevent weed growth through allelopathy methods by releasing compounds that suppress weed seed germination [62]. Potential cover crops that have allelopathy properties include *Secale* cereale or rye, *Vicia* villosa or hairy vetch,

Trifolium pretense or red clover, *Sorghum bicolor,* and mustards of the *Brassicaceae* family [63]. Finally, deep rooting cover crops that break up and loosen the soil tend to hinder the establishment of weeds that tend to thrive on compacted soils.

- Pest Control

Cover crops are increasingly utilized as part of integrated pest management programs. They can form part of a *'trap crop'* strategy to produce an environment that will appear more favourable to predatory insects [64]. When this strategy is successful, most predatory insects will inhabit the cover crop where they can be vacuumed up by a high power specially designed vacuum system from the cover crop [65]. Alternatively the cover crop selected may provide a favourable habitat for other beneficial insects, which are predators of the pests that the primary crop need to be protected from [66].

- Disease Management

Research has shown that cover crops can be utilized for reducing fungal diseases in crops [67] and parasitic nematodes [68] through the allelopathic release of glucosinolade artifacts from plant cell tissues [69].

- As a method to reduce *greenhouse gases*

Carbon sequestration in soil can be enhanced through no-till farming, residue mulching, cover cropping and crop rotation [70], which has been promoted by some scientists as a strategy to help offset the rise in atmospheric CO2 levels [71].

There are a number of limitations of cover crops and green manures. Although the retention ability of soils under cover crops is great, cover crops during growth also absorb water which can become an issue of concern in drought situations and semi arid areas like Australia, particularly in Spring when growth conditions are good. In these situations there will most likely bring the need for a tradeoff between reduced soil moisture due to the cover crop and available moisture for the newly planted or flush growth from dormant winter crops. The economics of investing in a cover crop verses the benefits needs to be assessed and some trial and error may be required in finding which cover crops may be the most suitable for the aromatic crops grown. Nevertheless, if integrated into the farming system successfully, cover crops and green manures are one more potential labour saving field management tool.

Finally, the factors to consider when selecting a green manure/cover crop include;

a) The sowing times that best meet the specific purpose of the green manure/cover crop,

b) The root system of the cover crop and its effect on the soil, *i.e., deep roots will loosen the soil, while a fibrous system will add organic matter to the soil*,

c) The average biomass generated by the cover crop and amount of N it will contribute to the soil,

d) The types of weeds, pests and diseases the green manure/cover crop will suppress,

e) Any allelopathy produced by the green manure/cover crop,

f) What types of pests and diseases the green manure/cover crop will host,

g) What beneficial insects will the green manure/cover crop host, and

h) What potential synergies can be achieved between the green manure/cover crop and the primary crop [72].

A list of potential cover crops is shown in Table 10.4. below.

Table 10.4. A List of Some Potential Cover Crops.

Botanical Name	Comments
Alysicarpus vaginalis	Good for clay type soils, regenerates through seeds to maintain cover
Calopogonium mucunoides	Introduced into S.E. Asia. Shade suppresses growth, but cattle don't eat it.
Canavalia ensiformis and ***gladiata***	Introduced into S.E. Asia, good source of nitrogen, short term (seasonal) cover.
Cassia pumila	Good for erosion prevention.
Dolichos hosei	Indigenous in Borneo, creeping plant for weed suppression. Grows well under shade.
Glycine max	As a high nitrogen cover crop, which can be ploughed in.
Indigofera sumatrana	Has good nitrogen value.
Mimosa invisa	A wide sprawling cover crop with a life of around 1.5 years. Good weed suppressant.
Mucuna deeringiana	Good as a supporting cover crop.
Passiflora laurifolia	Produces hydrocyanic acid.
Phaseolus lunatus	Short duration cover crop with good nitrogen value. Good weed suppressant.
Tephrosa vogelii	Hardy regenerating plant, with some insecticide properties.

Animal Manures

Most animal manure is made up of the excrement of plant eating animals like cattle, goats, sheep, and poultry. Animal manures contain nitrogen and a large number of elements necessary for plant health. These include phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S). Animal manure also contains organic matter, which can improve soil structure, water holding capacity, improve aeration, promote beneficial organisms and tilth of the soil. The nutrient value of animal manure varies according to the type of animal, the type of feed the animal consumes, the geographical location and climate. The potential single animal production quantity per year and range of manure nutrient values from various animals are indicated in Table 10.5. below [73].

Basically, most meat eating animals are not suitable as a source of manure. Although a large number of other animals provide sources of manure, hog manure is not advisable due to its strong odour. Dog and cat manure should be avoided because of the potential for parasites [74]. A recent study has shown that livestock antibiotics and hormones can be taken up into organic crops through the soil system. If non-organic manure is used, the integrity of farm inputs will be compromised [75].

Animal manures can be utilized directly as a fertilizer for a crop. It can also be incorporated into a compost or natural fertilizer mixture, manufactured at farm level for field application. Animal manures can also be used for improving soil nutrient and element content at a pre-planting stage. It is advisable to specifically analyse the source of animal manure for its nutrient values as well as existing soil fertility levels so correct field application calculations according to crop nutrient requirements can be made.

Table 10.5. Potential Single animal Manure production per year and Nutrient Value Range

Poultry (Chicken)	Goat	Sheep	Cattle	Manure Source
9.0-13.5	5.0-7.9	5.0-7.5	7.0-15.0	**Single Animal Tonnes/Year**
1.2-3.8%	1.2-3.2%	1.4-2.7%	0.6-3.0%	**N**

1.0-3.0%	0.4-1.2%	0.5-2.0%	0.2-1.2%	**P**
1.0-3.2%	0.2-3.0%	0.5-3.4%	0.6-3.4%	**K**
4.8-17.0%	1.0-3.0%	1.0-3.8%	5.0-15.0%	**Ca**
0.4-1.4%	0.1-0.8%	0.4-1.0%	0.5-1.5%	**Mg**
0.035-0.09%	0.018-0.08%	0.04-0.06%	0.014-0.13%	**Mn**
0.13-0.48%	0.166-0.4%	0.8-1.0%	0.07-0.5%	**Fe**
0.004-0.25%	0.001-0.014%	0.001-0.003%	0.001-0.015%	**Cu**
0.002-0.067%	0.01-0.045%	0.009-0.07%	0.006-0.07%	**Zn**
0.002-0.005%	0.001-0.006%	0.005-0.02%	0-0.006%	**B**

Intercropping

Intercropping is a way of planting crops to emulate the diversity of nature through the creation of a multi-crop regime within the same area in the field at the same time, with a crop selection that will create some sort of mutual benefit to assist in improving productivity. Intercropping can be considered part of farmscapping crop layouts which should be designed to take advantage of natural interaction between two or more crops. This is in contrast to the mono-cropping alternative which is primarily designed to facilitate the use of farm machinery and chemical applications on the field over a production cycle in an extensive manner.

The primary benefits of intercropping are;

a) to create greater yields and productivity on a given piece of land through total utilization of space, which may not occur through mono-cropping, *i.e., growing tall and short crops in a canopy arrangement or deep and shallow rooted crop mixes*,

b) to utilize other crops to protect the field through windbreak arrays, double or multi tier shade arrays and for pest management,

c) to assist in enterprise diversification, which leads to both risk aversion and the evening out of income inflows over the year, and

d) to encourage maximum biodiversity of the farm habitat, which will assist in limiting and reducing pest and disease outbreaks [76].

Intercropping can be considered a major strategy for pest and disease control, eco-system management and sustainability.

The primary principal behind intercropping is that a diverse system containing a number of plants, animals, birds, insects and microorganisms will have a much lower propensity to have pest and disease outbreaks than a less diverse environment like mono-cropping [77]. Pest and disease outbreaks occur much more frequently in less dense habitats [78]. Mono-crop situations are much more attractive to insect herbivores because under this type of crop regime food resources more concentrated food than would exist in a mixed environment [79].

A well thought out and designed intercropping environment can greatly enhance field resistance to pest and disease infestation, through a variety of methods. The intercrop environment if well designed will disrupt the ability of insects to search and find useful plants

to infest through its diversity. Through the selection of certain plants, insect olfactory and sight senses can be confused to assist in camouflaging potential host plants [80]. Crop diversity also attracts natural enemies due to the availability of foods like nectar and pollen, and favourable shelter and micro-climates [81].

In addition to developing an intercrop situation into a camouflaged environment, plants can be selected to perform the role of a trap, repellent or companion crop.

Companion crops are plants that discourage insects from feeding on the primary crop. Companion crops also assist in providing nutrients to the primary crop in a similar manner to cover crops discussed above. Any plant that acts in a beneficiary manner with another such as assisting to repel or trap insects, providing protection from wind as a windbreak, etc., can be considered a companion crop. Table 10.6. shows a number of aromatic plants that can be utilized as companion crops.

Repellent plants employ a strategy to avoid, deter and/or repel insect pests. Very often, plants utilize more than one method to repel insect pests. Plants through the metabolic system produce a number of chemicals in their roots, leaves, stems, flowers, barks and fruits, which through odour, toxicity, blocking biological functions or mimicking, can disturb the lifecycle habits of insect pests. Aromatic herbs can deter insects in one of three ways; by masking, repelling or killing [83]. Examples of masking plants would include thyme (Thymus spp.) and Sage (Salvia officinalis), repelling citronella (Cymbopogon nardus), clove (Eugenia aromaticum), and peppermint (Mentha piperita) , and killing, pyrethrum (Tanacetum cinerariifolium). Some plants block insect biological processes. One such case is substance produced by Ageratum houstonianum or blue billygoat weed that blocks insect juvenile hormones which kills off insect larvae by forcing them to molt prematurely [84]. Finally, some plants can produce mimic natural hormones to confuse insects. The wild potato (Solanum berthaulthii) produces a mimicking hormone that is similar to the alarm pheromone of aphids, which confuses and causes them to disperse [85].

Table 10.6. Some Aromatic Plants that can be Utilised as a Companion Crop.

Plant	Botanical Name	Potential Use as a Companion Crop
Basil	*Ocimum basilicum*	Helps to repel flies and mosquitoes
Catnip	*Nepeta curviflora*	Repels fleas, ants and rodents
Caraway	*Carum carvi*	Helps break down heavy soils
Chamomile	*Matricaria recutita*	Deters flies and mosquitoes. Assists in strengthening nearby plants.
Dill	*Anethum graveolens*	Attracts predator wasps
Fennel	*Foeniculum vulgare*	Repels Flies, fleas and ants
Garlic	*Allium sativum*	Said to enhance the production of essential oils and deter pests [82].

Geranium	*Pelargonium spp.*	Deters insects and encourages bees
Peppermint	*Mentha piperita*	Repels cabbage white moth keeping brassicas free from infestation
Oregano	*Origanum vulgarie*	Provides ground cover and humidity for plants.
Parsley		Beters some beetles, improves some plant growth
Rosemary	*Rosmannus officinalis*	Deters some mothsw and beetles
Rue	*Ruta graveolens*	Keeps cats and dogs off garden beds if planted around borders
Sage	*Salvia officinalis*	Repels moths
Spearming	*Mentha spicata*	Helps control ants and aphids
Tansy	*Tanacetum vulgare*	Repels moths, flies and ants. Toxic to animals.
Thyme	*Thymus pulegioides*	General insect repellent, improves growth of some plants.
Wormwood	*Artemisia spp.*	Can inhibit the growth of other plants near it. Also repels insects and keeps away animals.

Trap crops are plants that protect the primary crop from pests by attracting and retaining them. The trap crop releases an odour that attracts herbivorous pests to establish their habitat. Pests establishing themselves on the trap crop will emit aggregation pheromone to attract more to colonise the trap crop. Trap crops are either planted around the perimeter or in rows through the primary crop.

Intercropping is also used to assist in managing plant disease in reducing the potential for fungal, bacterial or viral infections. Row separation is effective in creating barriers to prevent spores from diseased plants traveling to populations of healthy plants and potentially infecting them. Mixed cropping also reduces the potential population that is adverse to any infection from any fungus, bacteria or virus.

Figure 10.4. Basil intercropped with Chili

The extent of crop integration and overlap of two crops in intercropping techniques varies. Some of the basic types of intercropping include;

- Mixed intercropping is where more than one crop is planted in the same land at the same time,
- Row cropping is where crops are arranged in selected rows. Sometimes this is undertaken in alternating strips of two or more crops,
- Relay cropping is where a fast growing crop is planted along side a slower growing crop, where the fast growing crop will be harvested before the slow growing crop is mature. Usually this method allows more growing area for the slower moving crop once the faster growing crop has been removed providing some beneficial effects of residual moisture from the area the fast growing crop occupied.
- Canopy cropping is practiced in many tropical areas where there are two or three canopy tiers within a cropping system. The top canopy will be trees that protect the other crops from the sun, wind and weather [86]. This allows more delicate plants to be planted below. An example of a multi tier tropical canopy system would be where coconut and cashew nut trees provide a protective upper tier, banana trees the middle tier creating a cooler micro-climate below where a number of crops like ginger, medicinal and aromatic crops can occupy.

Intercropping concepts and practices have developed through centuries of practice through tropical traditional farming. These concepts were taken up by contemporary researchers over the last couple of decades in efforts to develop intercropping as an integrated pest management and overall field management strategy. Determining the relationship between two crops within any intercropping system is extremely complex due to the large number of environmental and eco-system variables [87]. Some of the primary variables requiring consideration in planning an intercropping model include;

- *Allelopathy compatibility:* Do any of the intended intercrops emit any allelopathic compounds that would in any way inhibit the other crop?
- *Shading:* Will there be any advantage to the crop from shading?
- *Root Systems:* Will the root systems compete or complement each other?
- *Nutrients:* Will any of the intended crops assist in supplying nutrients to the other crop(s)?
- *Role in pest and disease control:* What role will the intended crop play in pest and disease management?
- *Competition:* Will the two intended crops compete or complement each other?

Understanding the above relationships will assist in determining spatial arrangements *(i.e., row, strip, mixed, relay or canopy intercropping)*, planting densities and planting times. A few examples of successful intercropping research with aromatic plants are shown in Table 10.7. below.

Table 10.7. Some Successful Intercropping Research with Aromatic Plants

Aromatic Plant	Nature of Intercropping
Palmarosa *(Cymbopogon martini Stapf.)*	Palmarosa and basil intercropped resulted in 17% increase in land use efficiency. Also palmarosa and soyabean + maize showed yield increases [88].
Citronella *(Cymbopogon wintereanus),* Lemongrass *(cymbopogon flexuosus),* Palmarosa *(Cymbopogon martini Stapf.)*, Patchouli *(Pogostemon patchouli)*	All crops grown under teak *(Tectona grandis)* showed increase in herbage [89].
Patchouli *(Pogostemon patchouli)*	Successfully cultivated under sesbania plantations in India [90].
Peppermint *(Mentha piperita L.),* Basil *(Ocimum basilicum L.),* Oregano *(Origanum vulgarie L.)* and Sage *(Salvia officinalis)*	Successfully cultivated with coffee in Mexico. Caffeine, rather than inhibit growth, stimulated growth of the aromatic herbs [91].
Ginger *(Zingiber officinale Roscoe)*	Reported to be grown as an intercrop with coffee. Also grown mixed with banana or other shade giving plants, eg., pigeon-pea, cluster bean (guar) under coconut [92].

Composting

Composting is widely used in organic farming as a primary method to condition and improve soil fertility. Through the breakdown of a wide variety of materials, compost helps increase the diversity of soil nutrients and organic matter. It is particularly useful for clay and compact soils to improve texture so that air can flow between the spaces. Composting also helps with improving the moisture and nutrient holding abilities of sandy soils. Increased soil biodiversity usually correlates with improved soil regeneration and disease suppression [93]. Composting is a valuable tool to use in conjunction with green manures and cover crops, forming part of integrated soil management programs. Composting makes a valuable contribution to farm sustainability and should be made from materials available on the farm site, or if necessary within the nearby surrounding area.

Composting involves breaking down biodegradable organic matter through a heat generating oxidative process where the materials within the biomass pass through a hemophilic phase leading to the temporary release of phytotoxins before producing carbon dioxide, water minerals and stabilised organic matter, called compost [94]. Composting is a necessary process in the preparation of organic matter before being applied to the field. This is necessary, principally for sanitary purposes although composting also assists in breaking down the material into particle size so that can easily mix with the soil soon after field application. Heat generated from the process should be enough to kill off pathogens, dormant weed seeds and deter any vermin. The process of composting is shown in Figure 10.5. below.

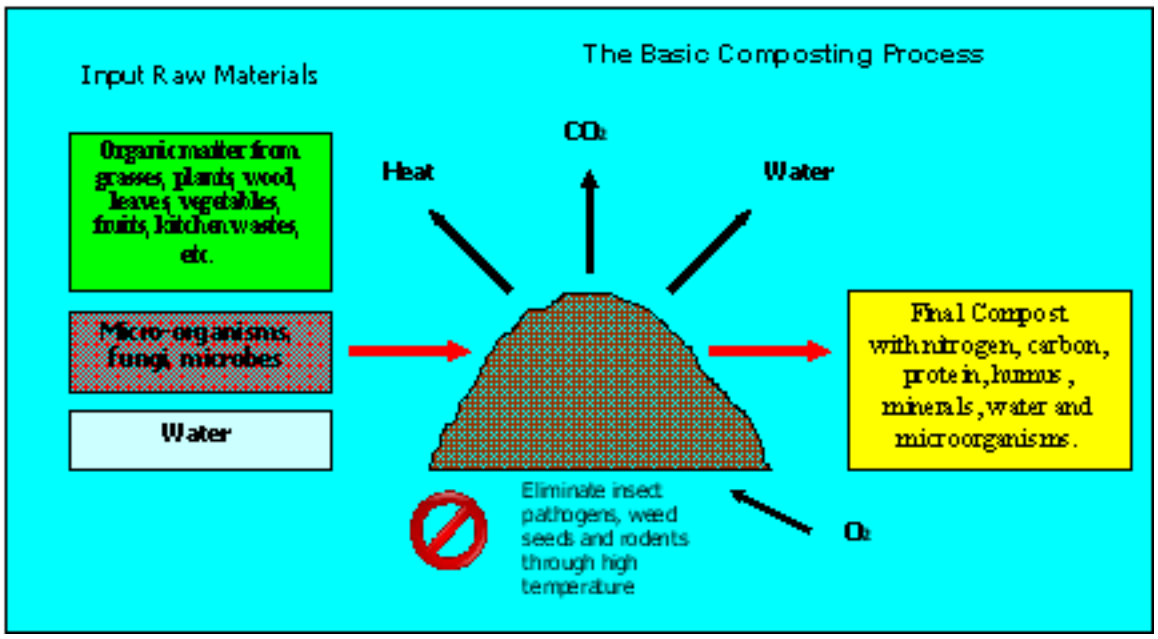

Figure 10.5. The Basic Composting Process

Through the introduction of microorganisms, fungi or bacteria and the generation of heat through energy-nutrient exchanges, composting speeds up the decomposition process to return organic materials back to the beginning of the food chain; the soil. The composting process goes through three distinct stages. During the first stage *(mesophilic stage)*, simple structured materials degrade as the temperature of the compost heap rises to 30-50°C. During the second stage *(thermophilic stage)*, where the temperature of the compost heap rises to 45-65°C, cellulose structures begin to decompose and pathogens, weed seeds and microorganisms are killed. During the final stage *(Curing stage)*, the compost heap begins to cure as the temperature decreases, humus begins to form and some beneficial organisms establish themselves within the compost [95]. Composting time is influenced by the density of materials used and the speed that they can be broken down organically. Therefore heavy woods can take some time, even up to years to decompose. Grasses and cellulose materials can usually compost within 7-12 weeks.

The quantity of nutrients within the final compost material depends upon the quality of the organic raw material inputs. High nutrient organic inputs will produce high nutrient values in the compost and visa versa. The use of legumes in the compost will increase final compost nitrogen levels. Incorrect compost processing can lead to a heap that either fails to decompose of becomes foul smelling and full of pathogens. Failure to decompose usually signals an absence of aeration and moisture, while foul smelling heaps result from too much moisture and not enough oxygen. Pathogens and rodents are usually attracted through using materials like meat, cooking oil, bones, or cooked waste foods.

Some of the major factors that influence the effectiveness of the composting process are summarized as follows [96];

- **Microorganisms:** are responsible for the commencement of the degradation process. These can consist of various bacteria, fungi, actinomycetes, sometimes enhanced by enzymes.

- **C:N *(Carbon/nitrogen)* ratio:** Microorganisms need approximately 25 times more carbon than nitrogen for growth and reproduction. A compost heap should have the correct balance of carbon and nitrogen so that microorganisms will ingest carbon for energy and nitrogen for protein. The ratio of carbon to nitrogen is called the C:N ratio. Optimum C:N ratios for microbial activity range between 19-30:1 [97]. To make effective compost heaps, materials with high C:N ratios like straws must be mixed with materials with lower C:N ratios like manures. When composts have low C:N ratios, the carbon materials will be fully utilized by the microorganisms leaving free nitrogen which will be lost to the atmosphere [98]. Higher C:N ratios will take longer to decompose and require extra nitrogen from the surroundings. Too high a C:N ratio may prevent the compost heap from heating up and decomposing. In general the nitrogen content of the compost decreases as the composting process advances. Finished composts with high C:N ratios if added to the soil could immobilize nitrogen in the soil, suppressing plant nutrient uptake.

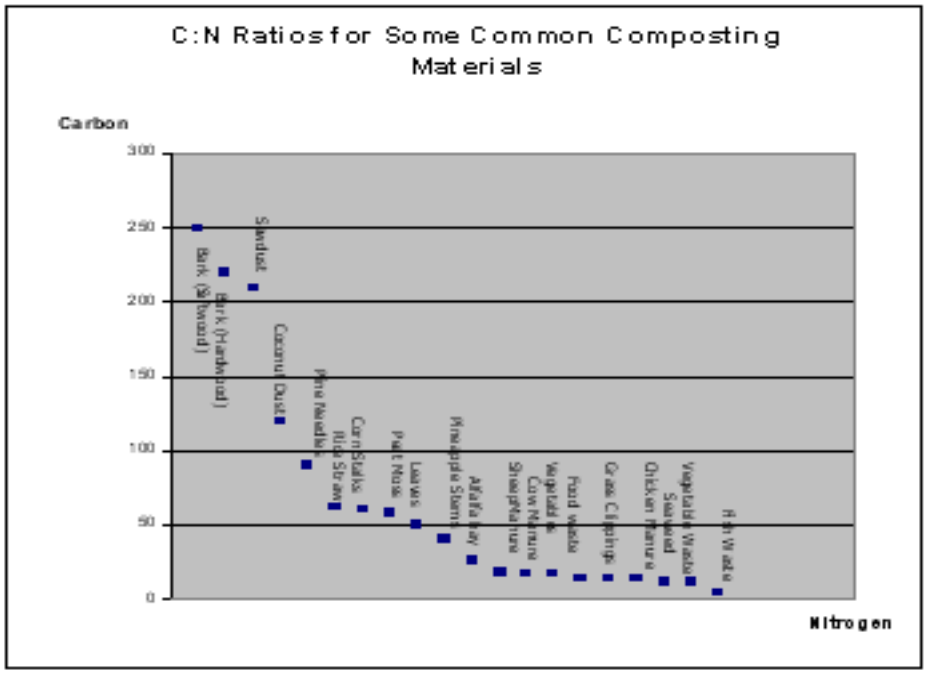

Figure 10.6. C:N Ratios for Some Common Composting Materials

- **Particle Size:** Organic materials should be ground into small particle size so that microorganisms can react with them. Large particle size will take much longer to decompose.

- **Aeration:** As the composting process is aerobic the compost heap must have access to aeration, so oxygen can enter in order for the microbes to decompose the organic materials. Most often compost heaps must be regularly turned over so that

aeration can be maximized. Poor aeration can lead to anaerobic microbes starting anaerobic digestion which may create foul rancid rotten egg type odours and promote the growth of pathogenic microbes that will decrease the quality of the heap.

- **Temperature:** The compost heap must reach the correct temperature ranges during the three phases of decomposition to create high quality finished material. It is important that the compost heap reach a plateau temperature for a specified period (usually a few days to a couple of weeks) to stabilize the compost and certification requirements [99]. This process is important for sanitation and the killing of pathogens and weed seeds within the compost.

- **Moisture:** Moisture is necessary to allow metabolic microbial processes within the compost. Without this the organic material will fail to decompose. A compost heap should contain between 55-65% moisture to ensure effective microbial activity. Excessively high moisture can restrict aeration and prevent aerobic processes. Due to natural evaporation, the moisture content of the compost heap must be continually checked and more moisture added if necessary.

- **Size:** The compost heap must be of optimal size to maintain enough moisture and keep in heat during decomposition.

Compost quality and organic integrity is directly related to the input raw materials. When collecting materials from waste sources outside the farm, it is very important to collect manures from animals that have not been treated with anti-biotics and hormones, and woods and sawdust that have not been chemically treated. Nitrogen, phosphorus and potassium contents will vary according to different materials used. The pH of composts during the composting period will be acidic, but after curing it should become slightly alkaline. The general properties of a good compost should be;

pH 6.0-8.0

<0.05 ppm ammonia

0.2 to 3.0 ppm ammonium

<1.0 ppm nitrites

>1.0% CO_2

Moisture content 30-35%

> 25.0% organic matter [100]

N 0.9-3.5%

P 0.5-3.5%

K 1.0-3.8% [101]

Some variations on the practice of producing compost are also in wide use. *Bokashi* is a method of introducing a starter culture *(called 'EM' effective microorganisms)* to organic matter to induce a fermentation process. Microbes usually introduced into organic matter convert oxygen into carbon dioxide, which is used by anaerobes to commence anaerobic fermentation of the organic matter [102]. This occurs at much lower temperatures than conventional composting. Molasses is usually added as an energy source with rice bran, oil cake fish meal, water and other organic materials. Fermentation through this process takes around 2 to 3 months and the *bokashi* is mixed with 2-3 parts of peat soil before application as a fertilizer or use as a potting mix. Usually an 'EM' culture is obtained and used to inoculate the organic materials. However 'EM' cultures can be developed through selecting microorganisms from the forest *(indigenous micro-organisms)* and/or yeasts and cultivating them under controlled conditions [103]. A similar method utilizing cooked rice, molasses and water with inoculation by airborne microbes called IMO to ferment organic materials in composts is widely used in East Asia [104]. Finally vermicompost, is a method that utilizes worms certain species of worms, (usually *Eisenia foetida* and *Lumbricus rubellus)* to create the compost in rotting organic matters such as manure, green leaves, sawdust, rice straw, banana stems, etc. This method is popular in India and also utilized in Thailand, Philippines and Malaysia. Several commercial producers exist in the US and Australia.

Mulching

Mulch is a protective cover, usually consisting of organic materials, which is placed over the soil to assist in crop cultivation in some way or another. Mulching involves the wide spreading of the mulch material over the field, especially around crop plants. Some of the benefits of mulching are;

- Assisting in maintaining even temperatures by slowing down earth cooling at night

and holding in heat through the protective mulch layer,

- Decrease temperature fluctuation which leads to less plant stress [105],
- To improve soil moisture retention by slowing up evaporation,
- To help control weed growth through blocking sunlight,
- To help in erosion control through preventing direct rainfall reaching the soil surface,
- To increase organic soil matter which will help soil moisture absorbency, and decrease soil density and compactness,
- To increase soil biodiversity through adding beneficial fungi to the soil upon decomposition, and
- To increase soil nutrients through mulch decomposition into the soil.

Mulch is usually applied to the soil at the beginning of a growing season to warm and protect the soil, maintain moisture and later assist in controlling weeds and eventually contribute to increasing soil fertility upon decomposition. This greatly assists in the economic use of irrigation, minimal herbicide application and long term soil fertility.

Mulch can be produced from a number of on or off farm organic sources such as manures, grass clippings, leaves, hay, straw, shredded bark, sawdust, sea shells, shredded newspaper, disused fabrics or compost. Other materials that are often used include chopped up or shredded car tires and plastic sheets laid over raised field beds. Waste materials that can develop foul odours should be avoided due to their potential to attract insect pests and rodents.

Figure 10.7. Mulched Lemongrass Cultivation using Sugarcane Waste

Mulching is important in overall strategies to develop soil fertility. Mulch decomposition is part of the process of plant recycling through organic material breakdown. Mulch decomposition increases the level of nitrogen and other nutrient levels in the soil. The long term use of mulch through increasing the organic content of tops soils should dramatically increase moisture absorbency capacity. This can greatly benefit sandy soil types. The increasing organic matter in the soil also increases the ability of air circulation within the soil, root penetration and growth. This can be of benefit to clay type soils. Mulch application generally increases enzyme and microbial activity in the soil [106], and reduces the incidence of surface diseases [107]. Mulch promotes an increase of worm activity with the right moisture conditions in the soil [108].

Mulching is also a major strategy component in integrated weed management. The level of protection a mulch can provide a crop will depend upon the thickness of the mulch, the coarseness of the mulch and how well external sources of weed seeds are managed. A well prepared mulch can provide 10-18 months protection from weeds from when it is applied [109].

Mulches should be optimized to be;

- Weed (and seed) free
- Pathogen free
- Biologically stable
- Of coarse particle size
- Non-toxic to the environment
- Reasonably dense
- Provide fair to good longevity
- Have good moisture absorbency
- Be easy to apply to the field
- Able to support beneficial organisms
- Be free of unpleasant and foul odours,

- Have readily available raw materials for production and
- Be of reasonable cost to produce [110].

As a result, some composting of mulches are required to meet the desired mulch characteristics above, *i.e., killing of weed seeds and pathogens through heat, fermenting the material to reduce potential toxic root compounds and providing a material capable of hosting beneficial microorganisms.*

Mulch longevity can be controlled through the type of organic materials used in its production. High carbon content materials like hay and straw will increase longevity, while high nitrogen containing material like manures will shorten mulch longevity. The ideal C:N ratio for a mulch would be between 25-30:1.

The extent of mulching that takes place on a farm will depend upon the availability of organic raw materials, the cost to prepare and apply the mulch and the benefits mulching provides the farm in the particular site specific situation. Mulching is widely used in intensive operations where high value seasonal and annual crops are produced. It is also used where high value tree crops are cultivated.

The spent biomass from tea tree oil distillation has become a popular commercial mulch. Due to the high carbon content of tea tree stems and leaves, tea tree mulch is relatively long lasting. After chopping the foliage at harvest tea tree mulch forms a woven and highly absorbent mat that retains soil moisture, inhibits weed growth and lasts around 12 months on the field [111]. Distillation acts as a sterilization process on the material [112] which makes it completely free of weed seeds and pathogens. A number of brands now exist on the Australian market with raw material supplied from tea tree plantation producers [113].

Crop Diversity

Crop diversity has greatly diminished over the last 50 years leading to a narrower range of plants that farmers plant as crops today. Diminished crop diversity has brought with it increasing problems of airborne pathogens, increased herbivores insect pests and increased numbers of viruses into agriculture [114]. Increasing crop diversity through mixed cropping within a farm eco-system is a method to dilute the concentration of airborne pathogens, herbivores insect pests and viruses [115]. Crop diversity is a useful tool in pest and disease management.

Natural Fertilizers, Minerals and Supplements

Ideally, if organic farming was fully sustainable, supplemental fertilizers from external sources would not be necessary. Farms, however due to soil, land and resources can only be sustainable to a certain degree where some outside inputs may be required. Purchasing external outputs is also a way of bringing in nutrients that may not necessarily be available (or be too costly to gather) within the farm eco-system. Natural fertilizer, mineral and supplement categories include;

a) Basic, semi and processed meals like fish meal, alfalfa meal, kelp meal, blood meal, crustacean meal, fortified compost blends, poultry manures, yard-waste composts, spent mushroom wastes, etc

b) Proprietary meal and organic fertilizer blends in various forms (compost teas, liquid compost extracts, effective microorganism blends, bacterial blends, fungal inoculants, seaweed extracts), including fish and other emulsions, biological fertilizers, blended organic composts and fertilizers,

c) Basic sustainable mined minerals, rock phosphates, gypsum, rock dusts, etc.

d) Bioactivators, humates, humic acids, enzymes, microbial teas, and catalyst waters, and

e) Proprietary minerals.

Basic and semi processed meals like bone, blood, kelp, fish and seaweed were the principal fertilizers used by many farmers before the advent of the 'green revolution'. Manures can be used as soil conditioners, especially with clay soils. Composts, which have been discussed above are very versatile. Some basic and semi process fertilizers are listed in Table 10.8.

Table 10.8. Some Basic and Semi Processed Fertilizers

Material	Application
Bone Meal	An animal based source of nitrogen, calcium and phosphorous that assists in building strong root systems.

Blood Meal	An animal based slow release nitrogen source for top growth. Blood meal does not contain salts like inorganic fertilizers, so can be used anytime on a crop.
Fish Meal	An animal based fertilizer which contains important trace elements.
Crustacean Meal	Contains nitrogen, of which some is slow released. Also contains P and K and chitin as a natural nematicide.
Seaweed/Kelp Extract	A marine based extract which contains important trace elements and other plant nutrients.
Animal Manures	Chicken manure is nitrogen rich, cow manure for potassium.
Mushroom Meal	Completely neutral pH with many plant nutrients.

Many basic meals are further processed into other forms such as pellets to enhance material handling and increase its residual effect during field use. These products may be generic or include some form of proprietary materials and come in different grades. *Complete fertilizers* containing nitrogen, phosphorus and potassium, as well as other nutrients in many cases, can be prepared on the farm, or purchased from a manufacturer. Compete fertilizers are general purpose and often contain seaweed concentrates, blood and bone, fish and chicken manures. However not all are organically certifiable.

A number of farm made and commercial products are used as compost teas, liquid composts, 'EM', bacterial and fungal blends. A number of compost by-products are useful for nutrient sources and crop fertilization. These include compost leachates, which are a dark coloured liquid that leaches out of a compost heap and compost extracts, which are prepared watery solutions of compost leachates. Compost teas are aerobically brewed mixtures of

compost extract with molasses and other nutrient materials like seaweeds through oxygen aeration through the liquid for a period of 24 to 48 hours to promote the growth of beneficial microorganisms [116]. Compost teas, although not very stable in sunlight interact extremely well with organic matter in the soil as well as providing nutrients to the plant. Compost teas are reported to play some role in preventing disease through reducing non-beneficial fungi [117].

Over the last 15 years EM-*bokashi* type composting has been gaining popularity in countries like the Philippines and Thailand. The economic downturn in 1996 encouraged conversion from conventional fertilizer to EM because of the savings to 'cash-strapped' farmers. Environmental concerns over the last couple of years have sustained interest in EM. In Thailand, some farmers have formed cooperatives to produce EM based fertilizers and a large number of rural based SMEs have gone into the fertilizer production business throughout South-East Asia.

Figure 10.8. Preparing vegetable material for fermentation in Sabah.

Effective microorganisms consist of *Lactobacillus plantarum, Rhodopseudomonas palustris, Sacchararomyces cerevisiae* and other bacteria which exist naturally in the environment. This mixture of bacteria is usually purchased or given out to farmers (by Thai Dept. Agriculture) to

inoculate compost to produce both liquid and soil based composts and fertilizers. A general recipe for an EM base liquid fertilizer used in Thai agriculture is as follows;

6 Kilograms	Banana, pineapple, papaya, other fruit and vegetable wastes according to what is available.
2 Kilograms	Molasses or raw sugar
20 Litres	Water
3 Kilograms	Chicken or cow manure
100 Grams	Effective Microorganisms

Procedure: Place all the ingredients together in a place them into a dark sealed tank. Place tank in a dark cool place for 90 days. Use the liquid 1:50 with water as a fertilizer [118].

Numerous biological products for agriculture are commercially manufactured as organic products. These products, either through micro-biological activity in someway enhance the soil, or contain fixed nutrients which upon application to the soil release these nutrients. This category contains a broad spectrum of products on the market, which begin with biological fertilizers based on organic nutrients. A number of specialist products like biological activators that promote microorganism growth and proprietary liquid humates (humic acids) are offered for specialist functions. The next group of products include enzyme plant activators, which enhance plant growth through *"bring(ing) out the life energy that is inherent in plants"* [119] and into the esoteric [120] with cosmic fertilizers. Many organic products are developed and marketed with some form of innovative media and/or delivery system to make the product more convenient to use by the consumer.

In poorer soils, mineral deficiencies will exist that will require attention. Several natural inorganic rock materials are allowed in organic farming for the purpose of addressing important mineral imbalances. Mineral source materials must not be chemically treated and contain no heavy metals or substances that will contaminate the soils [121]. These inorganic minerals are extremely rich in specific nutrients and can provide benefits to deficient soils. A list of some generally allowable minerals are shown in Table 10.9. below. These are most often applied as ground or powdered forms.

Table 10.9. Some Generally Allowable Minerals in Organic Farming.

Mineral	Application
Natural Phosphates	Important nutrient for root growth and flowering. Good for seedling transplanting. Helps to bind sandy soil.
Mineral Potassium	To promote flowering and fruiting or potassium deficiencies (i.e., reduced growth, browning of leaf edges, etc) occurs.

Calcareous and Magnesium Amendments	Control of pH (decrease acidity)
Clay (bentonite, perlite, zeolite)	Soil conditioner, to absorb moisture
Magnesium rock, Kieserite and magnesium sulphate	To overcome Mg deficiency symptoms in plants. Also helps to break up soil.
Gypsum (Calcium Sulphate)	To help break up the soil and provide calcium for high calcium requiring crops.
Sodium Chloride	Disease prevention [122]
Sulfur	To provide high sulfur requiring plants.
Trace Elements (boron, copper, iron, manganese, zinc)	Important nutrients

Many companies are producing proprietary products based on rock minerals for organic agriculture. An example is AZOMITETM mined from volcanic ash, rich in minerals and trace elements and certified organic in both the United States and Australia [123].

Many commercial organic fertilizers are sold as soil conditioners or soil amendments and don't display a nutrient rating on the label. As most organic products are low on one or more major nutrients, caution is needed in purchasing these products to solve specific crop fertility issues. One of the greatest advantages of organic agriculture is the lower cost of inputs, replacing purchased fertilisers through *on-farm production* of nutrients. Purchasing outside products *(especially considering more organic fertilizer is needed over inorganic due to lower concentrations)* could negate some of the cost savings organic practices bring to a farming system.

Insect and Disease Control

Insect control within an organic farming regime is primarily concerned with managing relationships within the farm eco-system with the objective of achieving balanced insect populations, which do not pose a major threat to crops. Emphasis is placed on preventative practices and measures. Curative or reactionary measures are only used if insect populations break out of control. Managing insect control within a *bio-intensive integrated pest management (Bio-IPM)* framework is driven by forecasting and monitoring. These plans are implemented through preventative practices through three major categories. Cultural and

biological controls manipulate the environment according to a farmscapping plan. Mechanical controls are used to supplement cultural and biological practices. Curative measures utilizing biological and organic pesticides are used if other methods fail to control insects and they become pests. An overview of organic insect management is shown in figure 10.9.

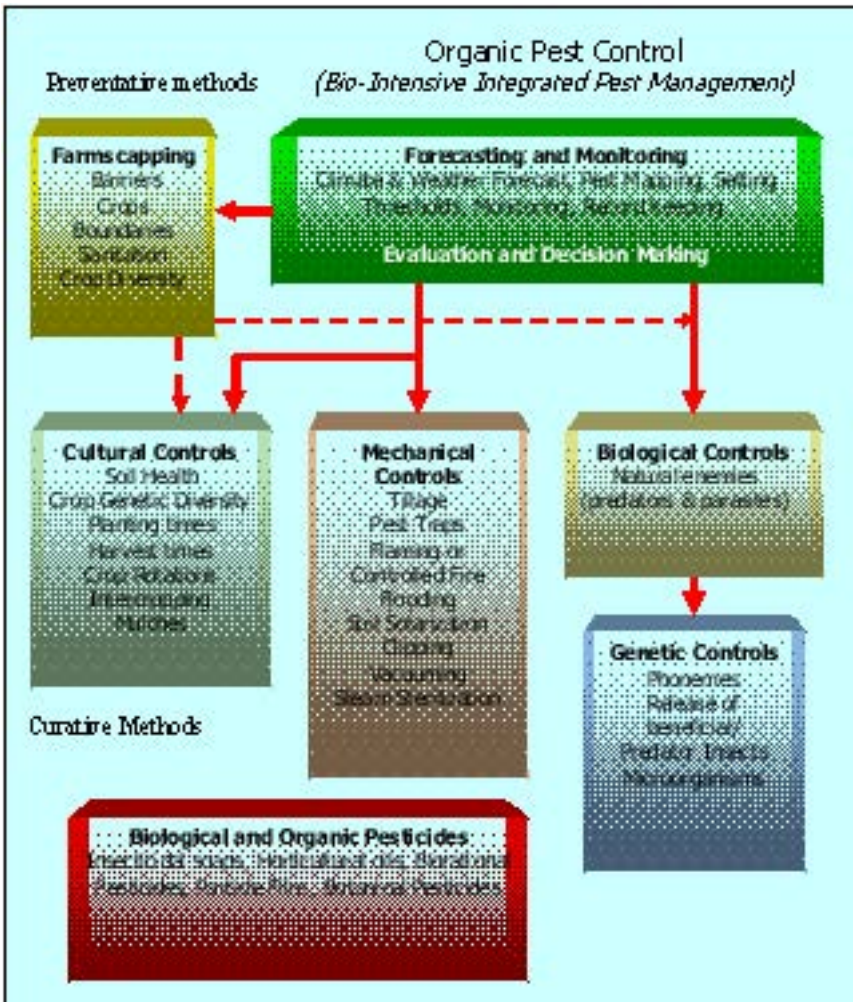

Figure 10.9. An Overview of Organic Insect Pest Control System

Within a bio-intensive integrated pest management framework insects are not considered pests until the population levels increase to a point where they can cause economic damage

to a crop. Thus an insect could be considered a pest during one period but not during another period. The level at which pests cause economic damage is called the *economic injury level (EIL)*. The *economic threshold level (ETL)* is where curative measures should begin to be taken to prevent insect population from reaching the economic injury level. Below the economic threshold level only preventative practices are undertaken to assist in maintaining insects around an *equilibrium population (EP)*, which will normally vary according to season. Therefore if population build-ups occur, the farmer must understand whether this build-up is a natural variation from the equilibrium population or a potential 'pest' outbreak. In a balanced eco-system, insect population increases will usually be countered by an insect enemy or predator, which will normally bring the population back down without outside intervention. If the increase of insect population is not brought under control by a natural predator, then outside intervention through biological and organic pesticides will be necessary. Figure 10.10. shows the intervention limits within the insect cycle.

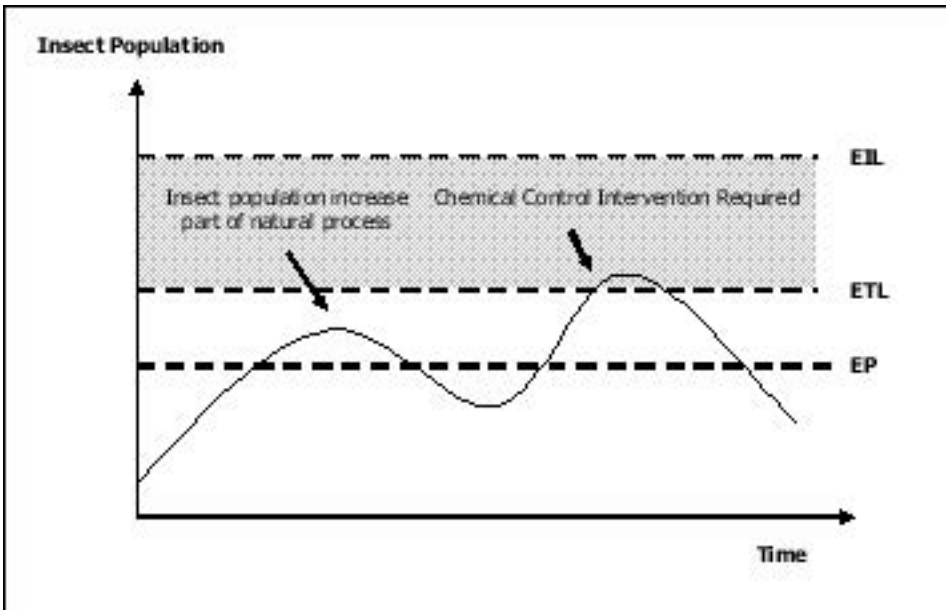

Figure 10.10. The Intervention Levels within the Pest Cycle

The successful control of pests begins with a thorough understanding of pests and pathogens within the site specific and crop context of the farm. The important basic aspects of knowledge that support the planning process include [124];

- **The historical status of the farm**, e.g., past pest severity and crops grown will provide some ideas to assist in anticipating potential pest problems,

- **The location of the farm**, is important in terms of soil fertility and conditions (drainage, water supply, etc.) and proximity of the farm to other farms and features that will influence pest incidence,

- **The types of crops planted,** will influence the types of pests and pathogens attracted to the site,

- **The design of the farm,** and cropping systems that incorporate pest prevention philosophies such as crop diversity and intercropping,

- **Knowledge about pests and their natural enemies** and

- **Knowledge about *bio-intensive integrated pest management* practices.**

The basic knowledge accumulated above, together with experience (and no doubt some advice) will enable the development of a farmscape designed around the preventative parameters *(i.e., crop diversity, intercropping, barriers, etc)* which serve as a platform to practice integrated pest management on the farm.

Before planting any crops, it is necessary to consider all the issues that contribute to pest and pathogen development on the farm. Information would include historical farm information, the latest weather and climate predictions for the next season, latest pest mapping information [125], the types of insects attracted by proposed crops, how these insects would arrive?, will they be followed by any potential predators? Finally, what farming methods would be the most appropriate given the potential pest risks?

The analysis taking into consideration all available information will enable the determination of *economic threshold level (ETL)* and *economic injury level (EIL)* for each identified pest and a total planned approach to pest management for the coming season. This should also be transformed into a specific monitoring and record keeping program to assess potential threats during the season.

Cultural controls involve the utilization of cropping practices that discourage habitation of the crop by unfriendly pest populations. Soil health and biodiversity is important for eco-system balance, which includes pathogen populations. Soil health and biodiversity is directly influenced by the amount of organic matter, pH, nutrient balances, moisture contents, and the basic soil type. Approximately 75% of insects spent some of their life-cycle in the soil [126]. Research has found that soils rich in organic matter tend to suppress pathogens [127], while imbalances in

soil nutrient ratios affect insect responses to plants [128].

Biologically diverse fields are more effective in repelling insects than mono-cropped fields [129]. Genetically diverse crops have a much higher resistance to pathogens than a genetically uniform crop [130]. Planning planting and harvest times can avoid the seasonal incidence of insect hatchings and migrations. Crop rotations can radically change the farmscape disadvantaging target insects. Companion and trap crops can be used to enhance protection against pests, as discussed previously. Mulching can help minimize the spread of soil borne pests. Experimentation with different coloured/synthetic based mulching materials has been successful in repelling a number of specific insect pests [131]. Table 10.10. provides a summary of cultural controls.

Table 10.10. A Summary of Potential Cultural Control Strategies

Strategy	Use/Benefit
Crop diversity (farmwide)	Maintain maximum plant biodiversity on the farm is the primary strategy of cultural control [132]. Decreased biodiversity leads to an unstable system, which will become prone to pest problems.
Crop Genetic diversity (single crop)	Genetically diverse crops show a higher resistance to pest and diseases than cloned crops [133].
Provide plants with a good start	Healthy and strong crops from the nursery planted in the field are less susceptible to insect attacks. This is particularly important during the transplanting stage.
Soil Health	Fertile and soils rich in organic matter and balanced nutrients contain less pathogens than unbalanced soils.
Planting and harvest timing	Can be used to avoid specific insect periods.
Intercropping/crop rotation	Change the environment that pathogens perceive and can be used to interfere with insect life cycles, through the disguising of crops. Crop rotation can eliminate pests associated with the previous crop. Multi cropping can provide natural barriers
Mulching	Can be used to provide habitat for enemies, *i.e., spiders*. Synthetic mulches can repel potential insects.
Cover crops	Certain cover crops can repel insects.
Sanitation	Removing potential breeding sites for potential insect pests, eg., nematodes.
Companion and trap plants	Used to attract away or repel insects from the primary crop.
Tillage	Tillage can dry out organic matter to ensure it doesn't attract potential pests.

Biological controls are primarily concerned with the use of living organisms to maintain balance within the insect population at equilibrium population levels. Ideally this occurs naturally where mammals, birds, insects, fungi, microorganisms and viruses act on each other within the natural eco-system food chain without any intervention. But situations often arise where some part of the chain is absent within the farm eco-system, requiring intervention. This occurs with the introduction of a mammals, birds, insects, fungi, or microorganisms to become parasites or predators within the eco-system. This requires careful study within the planning stage to determine which insects are threats at what population levels, where in the food chain

they exist and what are their predators and enemies.

Traps with synthetic pheromones are increasingly used in farming with great success in some industries. According to the Australian CSIRO, 90% of chemical insecticides have been eliminated in the orchard industry in Australia with the use of chemical sex attractants [134]. Pheromone traps confuse the male insect, which disrupts the mating cycle. Pheromone traps can be used either for detection and monitoring and/or eradication of insects.

Mechanical controls assist as supplemental practices to assist cultural and biological controls. A number of mechanical methods exist which can be utilized to suppress insect population growth as follows;

- As many insects inhabit the upper area of the soil, tillage can expose and kill insect eggs and larvae by bringing them to the surface to dry out under the sun's radiation.

- Coloured pest traps covered with non-drying glue attract and trap insects within the crop itself. This is useful against a variety of insects and can also be used as a monitoring as well as a control tool [135].

- Flaming and controlled fire are primarily weed control methods, but they destroy potential insect habitats.

- Flooding of crops is sometimes used to control certain pests, where there is ample supply of water in tropical areas [136]. However this method should be used sparingly due to crop and soil damage potential from flooding.

- Water pressure during irrigation is sometimes enough to remove some pests like aphids from crops. This may have to be done repeatedly to prevent them re-attaching themselves.

- Soil Solarization involves covering the soil with a plastic cover for a period of 4-6 weeks during periods of hot weather. This will heat up the top 15 cm of soil, killing a wide range of insects, fungi and weed seeds. This is an especially effective method for killing insects which inhabit the root systems of crops, e.g., fungi and nematodes.

- Row covers are flexible, semi transparent woven or plastic materials that cover the crop to exclude insect pests. Row covers also enhance crop growth through increasing soil temperature, reduce wind damage. Row covers are effective for airborne pests, but totally ineffective for soil borne pests.

- Using vacuums to remove insects from plants is becoming more popular. Trees and

mulches are directly vacuumed with the insects traveling into a disposable cartridge lined with sticky gel to trap them. Vacuums can be hand held or attached to a tractor.

- Steam treatment on soils has been used in greenhouses and small fields in the United States for a number of years. This method has also been used effectively on larger fields through a steam rake attached to a tractor [137]. Steam effectively kills pathogens through heating of the soil to levels that cause protein coagulation or enzyme inactivation [138]. Although this method is effective, there are a number of practical problems associated with it over large acreages.

Some methods like pest traps are widely accepted. Many of the other methods, although suitable for small areas, have limited application on large farms, *i.e., netted greenhouses*. However, through innovative engineering developments, some of these methods are gaining popularity and coming into wider farm use as pest control strategies.

Figure 10.11. Netted Greenhouses are Popular for Insect

Protection

Cultural, biological and mechanical controls are the prime management methods of pests and diseases within a bio-intensive integrated pest management system. This pro-active approach is intended to avoid the outbreak of pests with the aim of minimizing inputs through reducing the need for intervention agents and chemicals [139], thus reducing field overhead costs. However, bio-intensive integrated pest management requires a deep ecological knowledge to adopt a holistic approach [140], which is extremely difficult, if not nearly impossible to practice flawlessly according to Altieri [141]. Bio-intensive integrated pest management changed the paradigm from total eradication of pests to managing populations

of insects within a farm eco-system where curative measures should be used as an option of last resort to prevent economic losses [142]. This recognized the dangers that pesticides had to the environment and also the non-selectivity in many chemicals on beneficial insects as well as pests.

Organic certification systems allow the use of a number of pesticides. Bio-pesticides used in organic farming fall under the categories of;

- Biorational, derived naturally from microorganisms,
- Particle film barriers, comprised of natural materials that create a barrier between crop on insect,
- Insecticidal soaps and plant oils,
- Botanical pesticides, and

- Other organically acceptable concepts.

Bio-pesticides are not only used by organic farms, but also by some conventional producers due to consumer pressure over food health, security and pesticide exposure. The bio-pesticide market is one of the fastest growing chemical industries with an estimated global value of USD 260 million in 2005, projected to be around USD 1.0 Billion by 2015 [143]. This still represents less than 2.0% of World pesticide usage [144].

The general advantages of bio-pesticides over conventional pesticides is that they have multiple modes of activity against pests, low restricted entry intervals between 0-4 hours and generally exempt from maximum residue limits [145]. Cost and immediate efficacy are bio-pesticide disadvantages, restricting wider use. Also the increasing selectivity of synthetic pesticides is another factor restricting the future growth of bio-based products [146].

Biorational Pesticides

Biorational pesticides are a rather loosely defined group of pesticides that are generally derived from naturally occurring compounds or are formulations utilizing microorganisms. These include a wide range of microorganism based products, plant and pathogen mimicking compounds, composts and 'EM' based pesticides (compost teas, etc).

Microbial insecticides can be derived from viruses, bacteria, fungi, protozoa or nematodes, or toxins produced by these organisms, formulated into a conventional pesticide form as a spray, powder or liquid. Most of these microorganisms are found in soils and produced into pesticides through fermentation [147]. Many microbial insecticides are selectively toxic to a single species or closely related group of species [148] and present very low toxicity threats to other plant or animal species, including humans.

One of the most common commercially produced microbial insecticides is one that contains the spores and protein crystals (endotoxin) of the bacteria *Bacillus thuringiensis (Bt). Bt* is not a contact poison and must be ingested by insects to be effective. The spectrum of effectiveness against various insects depends upon the nature of the *Bacillus* strain, the product contains. The discovery of new *Bacillus* strains in the 1980s greatly widened the effectiveness of *Bt* against much wider ranges of insects. A second group of *Bt* bacteria isolated from the *Bacillus thuringiensis* variant *israelensis* enabled the killing of fly and mosquito larvae. *Bt* products are applied to crops in a similar way to conventional pesticides. However efficacy drops back rapidly in the environment, which often necessitates a number of sprays.

As each *Bt* insecticide controls only specific types of insects, it is necessary to correctly identify the target pests before making pesticide selections. Treatments must be directed

towards the parts of the plants that insects will eat. *Bt* insecticides have a slow knock down effect, compared to many conventional pesticides, as it will take over a day for insects to drop off sprayed plants once they have ingested the *Bt. Bt* also has a much shorter *half life* than conventional insecticides and should be sprayed on cloudy days to minimize UV radiation exposure.

Viruses, fungi, protozoa, and nematodes can all be used to produce microbial pesticides, but to date most of these processes are limited. For example, viruses must be produced in live insects, which is expensive and time consuming [149]. However, through further advances in biotechnology more products from these sources will eventually come onto the market, utilizing much more efficient routes of production.

Many compost teas are made on-farm, utilizing microorganisms to develop fermentation for pest and disease control. The products are manufactured as liquid composts with a number of materials that will create insecticide properties, such as neem, tobacco, galangal, citronella, etc, and applied as sprays. A simple formula for a liquid compost pesticide utilized in Thailand consists of;

5 Kilograms	Neem fruits and leaves (fruits preferred)
1 Kilogram	Tobacco Leaves
6 Kilograms	Banana, pineapple, papaya, other fruit and vegetable wastes according to what is available.
3 Kilograms	Molasses or raw sugar
20 Litres	Water
100 Grams	Effective Microorganisms

Particle Film Barriers

Diatomaceous earth is a naturally occurring chalk like rock consisting of the fossilized silica shell remains of diatoms. Diatomaceous earth absorbs lipids and moisture from insect exoskeletons, causing them to dehydrate and die upon contact. It is effective as a barrier against a number of insects and also as a soil additive. It is effect in arid-dry low rainfall regions, rather than tropical humid regions.

Particle film barrier concepts, based on natural mineral materials were developed in the late 1990s [150] and are an early example of the many new IP protected, organically certified agricultural products appearing on the market. Modified kaolin was applied to crops as a fine particle solution which left a residual protective coat that deterred insect contract through agitating the insects and preventing egg-laying [151]. The light colour of kaolin also makes the plant less recognizable as a host. This product is manufactured under the trademark SURROUND [152].

Insecticidal Soaps and Plant Oils

Insecticidal soaps have been popular in the nursery, horticultural and market garden sector

in Australia and New Zealand for a number of decades because of the non-residual properties and low toxicity of the product. Insecticidal soaps are usually manufactured from fixed (non-volatile) plant oils (palm, coconut, olive, cottonseed, etc.), saponified with potassium salts to neutralize the acidity and making the emulsion alkaline. Usually additives like ammonia and an essential oil like citronella, eucalyptus, nutmeg, rosemary, pennyroyal, clove, or tea tree oil would be added to enhance product efficacy. How insecticidal soaps actually work is still not fully understood. It is thought that the soap physically disrupts the insect cuticle or outer skin, causing toxic paralysis [153]. Another theory believes that the insects are suffocated during spraying and the irritation from the product forces insects to abandon the host plants [154]. It is important that insecticidal soaps sprayed onto plants must directly contact insects to be effective. Insecticidal soaps are effective against a number of soft bodied insects like aphids, scales, psyllids, whiteflies, mealy bugs, thrips, and spider mites. Hard bodied insects have the protection of their hard chitinous bodies. Insecticidal soaps are quite effective in intensive and confined areas, but of limited use in extensive farming due to the number of repeated applications required to maintain a zero insect infection. Insecticidal soaps due to their high pH tend to burn hairy leaved plants but usually safe to use on smooth leaved plants.

This type of formulation could be considered the 'grandfather' of a number of new *organic pesticides and fungicides* utilizing essential oils and encapsulation technologies, discussed in the next section.

White or horticultural oils are a name given to oils, sometimes emulsified in a soap base to control diseases and insects. Any number of oils including paraffin, mineral oil, canola, caster, sunflower, are used. These products are generally used to remove various fungi and scales from plants and trees and to control insects like aphids and spider mites. Some people manufacturing their own on-farm emulsions add either ammonia or vinegar to enhance insect repellency efficacy. In general these emulsions are sprayed directly over plants to coat and suffocate insects, or used as a rubbing agent for disease infected plants. Commercially, there are various products on the market with many variations of the product based on different philosophies and approaches. However traditional oils like paraffin are declining in use due to the long number of CH2 chains which brings up phototoxicity issues [154], which can be potentially fatal to the plant. In addition, these long chain oils may carry sulphur residuals and the film created by these oils can block the stomata (intake apparatus of the plant), preventing nutrients being taken up. White oils now tend to be light vegetable oil soaps with various additives to assist in killing fungi and spores and remove scales.

Botanical Pesticides

Botanical pesticides are a wide group, which utilize a variety of plants and their parts. Production processes are also widely varied, ranging from soaking of leaves and fruits in the case of neem, leading to mixtures of variable quality, to the steam distillation of essential oils and solvent extraction of pyrethrum from pyrethrum daises, in a standardized form. Botanical pesticides include both products that can be manufactured on the farm and commercially produced branded products. Generally, botanical pesticides are less harmful than other pesticides, breaking down easily and quickly in the environment.

Neem *(Azadirachta indica A.* Juss) is considered by many to be one of the wonder trees in our global bio-diversity. A native of India, neem is also found throughout South-East Asia and is also cultivated in Australia. Numerous applications of the tree have been practiced by indigenous communities over the centuries, which include as an insecticidal, antifeedant, acaricidal, insect growth regulator, nematocidal, fungicidal and antiviral agent [155]. Neem contains a number of active compounds, of which two *azadirachtin* and *salanin* [156] exhibit very potent insect intervention properties. They are present in most parts of the tree, but concentrated in the fruits. Neem does not knock down insects like conventional pesticides, but rather interferes with the feeding and reproductive lifecycles, confusing them until they are unable to reproduce and thus disappear [156].

Neem oil is not a true oil in the real sense, but a tincture that can either be extracted through solvents on a commercial scale or obtained through soaking out the active ingredients from the fruits and leaves in a bin or tank. Neem is a major input in the production of natural insecticides

at the farm level in Thai agriculture. The resulting tincture is very unstable and will lose activity within a very short period of time. Although a number of commercial products are in the market, standardization problems have stood in the way of neem gaining further acceptance as a major agricultural pesticide. Neem's efficacy as a human contraceptive [157] is considered by some authorities as a health and safety issue. Another variety of neem, *Azadirachta excelsa* is also used as a pesticide.

Pyrethrum based products are also rapidly growing in demand as a pesticide in agriculture. Pyrethrum has one of the broadest insect killing spectrums, of products on the market. Pyrethrum is solvent extracted from the flowers of *Chrysantemum cinerariifolium*, a highland or temperate climate plant. Natural pyrethrum was once the major ingredient for household insecticides before the advent of synthetic pyrethroids, which had a much longer residual efficacy. Natural pyrethrums are of low toxicity to mammals and one of the safest pesticides in use. One of its advantages is that it has a very quick knock down effect on insects through attacking the nervous system. However the substance is very unstable in UV radiation, breaking down very quickly. Pyrethrum is usually applied as a spray on crops during growth and maintenance periods.

As discussed in chapter 4, plants produce volatile and non-volatile metabolites that deter insects and other herbivores from feeding on the plant in a number of ways. More than 2000 plants have been investigated and found to posses these characteristics [158]. Much more interest has been taken in essential oil based insecticides over the last few decades [159], resulting in a number of products in the marketplace for pesticide applications. Table 10.11. provides a summary of some of them.

Table 10.11. Summary of Plant Extract/Essential Oil Based Insecticides

Plant Extract/Essential Oil	Application
Basil Oil *(Ocimum spp.)*	*Wide spectrum*
Citronella *(Cymbopogon nardus)*	*Wide spectrum*
Citrus Oils	*Wide spectrum*
Clove Oil *(Syzygium spp.)*	*Sitophilus zeamais, Tribolium castaneum*
Eucalyptus *(Eucalyptus spp.)*	*Wide spectrum*
Garlic Oil or extract *(Allium sativum)*	*Worms, aphids and beetles, also antifungal*
Lavender *(Lavendula spp.)*	*Acanthoscelides obtectus, Cydia pomonella*
Mint Oils *(Mentha spp.)*	*Wide spectrum, ants*
Nutmeg Oil *(Myristica fragrans)*	*Wide spectrum*
Pennyroyal oil *(Mentha pulegium)*	*Diamanu montanus*
Rosemary *(R. officinalis)*	*Sitophilus orzae, Tetranychus urticae*
Tea tree Oil *(Melaleuca spp.)*	*Wide spectrum, also antifungal*
Thyme *(Thymus spp.)*	*Plutella xylostella, Pseudaletia unipuncta*

A number of relatively young, specialized small companies are expanding in the area

of organic agricultural products. EcoSMART [160] utilizes essential oils of rosemary, clove, thyme, nutmeg and cinnamon as neural blocks to insect nervous systems in their range of new generation botanical pesticides. Biomor, a company in Israel has utilized tea tree oil in a range of fungicides, effective against a broad number of diseases in plants with no residuals or phytotoxicity [161].

Garden dusts are multipurpose insecticide/fungicides made up of a synthetic or natural plant derivative with a bulking agent. Garden dust is used against plant diseases like powdery mildews, bacterial blights, early blights, fire blight, anthracnose, alternaria blight, leaf spot diseases, brown rot, apple cedar rot, peach leaf curl, peach canker, stem blight, shothole, leafscorch, black rot, scabs and botrytis [162].

Garden dusts also provide some repellency against a number of insects. The usual active ingredient is *rotenone*, extracted from the roots of two tropical legumes *Lonchocarpus* and *Derris elliptica* [163]. Rotenone is a broad spectrum insecticide, effective against aphids, beetles, and caterpillars, but must be ingested by insects to be effective. Garden dusts can be directly sprinkled on plants or mixed with water and sprayed. As rotenone is very unstable when exposed to air and sunlight, it has a very short half life.

Two other botanical active ingredients that used in dusts and sprays include *ryania* extracted from the stems of *Ryania speciosa*, a native plant of South America and *sabadilla* from the seeds of the tropical lily *Schoenocaulon officinale.* Ryania is a slow acting poison to insects, but has a wide spectrum and works well in hot weather, unlike many other biopesticides. Its principal active ingredient is an alkaloid ryanodine. Sabadilla is effective against a number of insects, so will kill beneficial insects as well. Its active ingredients are cevadine and veratridine [164], extracted from the ground seeds of the sabadilla lily.

Finally, nicotine is extracted from tobacco for use as a pesticide. It is toxic to mammals through skin absorption. Nicotine kills insects through interfering with insect neural-transmitters between nerves and muscles. Nicotine is wide spectrum and used against aphids, thrips, spider mites and other soft insects. Nicotine as nicotine sulfate is usually applied as a spray and is suitable for warm weather use.

The area of biological organic control products will continue to develop in new concepts based on bacteria, fungi, viruses, protozoa, and nematodes, plant metabolites, enzymes, saponins, tannins, ozone, and botanicals, in line with public concern over food security.

Other methods of pest control have been experimented with. For example, ultrasonic pest control was discredited a few years ago through a number of ineffective products on the market [165]. Research has shown that insects use ultrasonic frequencies for communication [166]. This is an interesting area for pest research to reappraise.

Weed Control

Weed management is one to the greatest challenges to any organic farm. Weeds can be

defined as any plant which is a nuisance to or interferes with human activity or a plant which is not wanted and growing out of place [167]. Failure to react to early stage weed outbreaks can result in a large amount of lost time and labour manually extracting weeds. Weeds are a major problem in organic agriculture and need to be managed at a very early stage, especially in high rainfall tropical areas. Weeds compete and retard the growth of crops and can potentially create habitats for herbivores insects and pathogens. Weeds may pose a serious problem during early growth periods. At other times weeds may not be considered a problem as the primary crops are healthy and large enough to provide competition for potential weeds.

Weeds in a balanced eco-system can provide a number of positive attributes to a crop system,

a) where some deep rooted weed species can assist in bringing nutrients to the surface soil that would not otherwise be available to the crop,

b) be a very useful indicator of present soil conditions,

c) provide habitats for some beneficial insects, and

d) can contribute to the overall biodiversity of the farm eco-system, which may make it a more stable productive system [168].

Prevention is one of the fundamental components of integrated weed management. Like pest and disease management, weeds can be managed through an *integrated weed management* system, which is based on the following principals;

1. Knowledge of soil, crop and pasture systems,

2. Knowledge of weed species and how they affect soil, crops and pasture systems,

3. Use of mapping and monitoring systems to evaluate weeds populations and damage,

4. Knowledge of the appropriate available management options for weeds,

5. Making control decisions based on the above knowledge, using a combination of methods to control weeds, and

6. Monitoring the impact of weed management and evaluating its effectiveness on the weed species in relation to the soil, crop and pasture [169].

A balanced understanding of weed and crop ecology and managing them according to their biological differences will reduce the need for reactive weed control. The intensity of weeds is greatly influenced by weed populations of previous years. Weed management is a long term activity where the efforts of past years will show up in later years. Weeds are closely related to soil fertility and can be an indirect indicator of soil deficiencies, *i.e., some weeds will prevail when soil is too acidic or alkaline, soil structure poor, or under anaerobic conditions.* Weed populations tend to decrease as soil health builds up [170].

Through *integrated weed management,* weeds can be managed through cultural, mechanical (physical), chemical and biological means. Some common cultural practices that act as a preventative measure against weed development include;

- Crop rotation which helps to prevent weed seed carrying over to the next crop. Utilising differences in crop and weed biological timing can be of great advantage in weed management.

- Ploughing or harrowing a field before primary crop planting, where early germinating weeds can be killed through sun drying on the surface. This provides the crop time to establish itself without competition from weeds. Future weed growth in the field with an established crop will be more difficult due to competition with the main crop. The success of this method depends on the type of weeds. Ploughing or harrowing may bring up deeper weed seeds to the surface, which will germinate and increase weed populations.

- Altering plant spacings to denser crop populations to eliminate potential places for weeds to grow.

- Cattle, sheep and goat grazing in the field is successfully used in tea tree plantations in Australia [171] and Malaysia to control weeds without any damage to the crop. Grazing is probably one of the most important tools in organic farming for weed control, subject to the potential of the grazing animal to inflict damage to the crop.

- Buffers between crops help prevent weed seeds and spores traveling by wind and contaminating the field.

- Cover crops can smother weeds, prevent sunlight from reaching the soil surface and generally compete with weeds to prevent their growth. Some cover crops when mowed and killed will release allelopathic toxins into the soil which hinder weed growth [172].

- Similarly to cover crops, mulches also smother the ground to prevent weed growth in the field. Plastic strips can be laid down crop rows to prevent weed growth, and

- Modifying the soil pH to levels outside optimal target weed growth is another approach.

Other preventative measures include utilizing only seed clean of potential weed seed and spore contamination, and cleaning tractors and other agricultural tools and equipment before transferring them from field to field to prevent cross contamination.

Figure 10.12. Plastic Sheeting Laid and Prepared

For Planting by Melting Holes for Plant Growth

While good cultural practices will decrease weeds substantially, mechanized weed management strategies are also needed to assist in weed management. Some potential mechanical and physical weed management practices include;

- Regular observation and manual weeding cannot be avoided in any organic crop system. A few weeds pulled out this year may prevent a much larger number of the same weeds, the following year or season. Some manual or tractor fitted propane flame burners are used to assist in manual weeding and are used widely with great success.

- A number of innovative crop weeders have been invented and developed to mechanically weed specifically identified weeds, with the ability to till very close to row crops without disturbing them. These weeders are usually purpose built by university agricultural engineering extension schemes. These weeders can be used both pre- and post crop emergence and therefore have the capacity to dramatically reduce weed competition under the specific site circumstances they were designed for [173].

Until very recently organic farmers had very few options through chemical means to control

weeds. Early organically certifiable herbicides were based on vinegar, citric acid, and some essential oils. These products did not even come close to matching conventional herbicides [174]. Most organic herbicides on the market generally rely on acidic or alkaline pH to 'burn' out weeds. Further, most organic herbicides are non-selective. Organically certifiable herbicides is an area of new development for weed control through microbial, fungi, bacterial, enzyme or plant extract routes in the near future. For example, a *d-limonene* herbicide, under the brand name of *Nature's Avenger,* is effective through stripping the wax coating of weeds, allowing them to dehydrate and die [175]. According to studies by Marambe and Sangakkara during the 1990s, effective organisms (EM), used in *Kyusei nature farming* are very effective in suppressing long term weed growth [176].

Biological weed control involves the utilization of pests, diseases, viruses, nematodes or bacteria to control weeds. The biological control of weeds is still in its infancy, and these methods are not currently in wide use. There are three main types of biological weed strategies. The classical approach involves the release of a small number of natural weed enemies in weed infested locations to control weed outbreaks. Natural enemies are selected from arthropods, nematodes, vertebrates, and other microbial organisms. Augmentative biological control strategies involve using natural enemies against weeds at times when the weed population is most susceptible to attack. Usually microbial organisms are used. The ecological approach is a continual process where known natural weed enemies are promoted, so their populations are enhanced throughout the farming cycle.

Tillage

Tillage is a practice that has both benefits and disadvantages. Tillage is a major weed control strategy, which assists in crop residue management, helps to aerate the soil and prevent anaerobic decomposition, helps to integrate manure with the top soil and destroy potential pest habitats.

Minimum or conservation tillage is not mandatory in organic farming, but encouraged because of the some beneficial effects to soil health. These include the promotion of earthworm and microorganism populations in the soil [177], lowering the cost of field operations through fuel and labour savings, improving soil tilth, increasing organic matter [178], reducing water loss and soil erosion [179].

Interest in some of the benefits of conservation tillage has led to the development of chisel ploughs that can restrict tillage to the upper parts of the soil where the biologically active layers exist. Crop residues and mulches are mixed in at this level to maximize organic material in this layer. This assists in maintaining aerobic decomposition. Other methods include mulch tillage, v-cutting, rolling and mowing which maintain cover crops mulches on top of the soil [180]. Ridge tillage can also be practiced where raised permanent ridges in rows exist on fields for crop bedding. Ridge tillage assists in mechanical methods of weed control greatly. Zone or strip tillage minimizes the impact of harrowing the field, which has some advantages in cold, wet regions.

Comparative analyses of tilled and no-tilled soils consistently show that no-tilled soils exhibit improved nutrient and water holding capacity [181]. However there are many problems preventing universal implementation of conservation tillage due to absence of alternative non-chemical weed control methods and limitations of its benefits in some soil and climate conditions like tropical areas [182].

Farmscaping

Farmscaping provides the structural basis of a holistic and ecological approach to farm management. The farmscape should be developed in a way that the farm is integrated with the surrounding landscape. An important influence on the success of converting from a conventional to an organic farm, and the future sustainability of the farm will depend upon initial farmscaping of the property. The farmscape will become the platform and determine the ease in which;

- Pesticide use can be minimized,
- Mulching and composting can be undertaken on-farm,
- The threat of external contaminations can be minimized, and
- Improve the quality of biodiversity in the ecosystem.

The farmscape will have a major impact on soil health and pest and weed management frameworks and strategies. Farmscape design will also influence the integration of farm wet lands, ponds, dams, roads, barriers and buffers, fields and other infrastructure with the surrounding biodiversity and eco-system. Table 10.12. lists some important farmscaping issues.

Table 10.12. Some of the Important Farmscaping Issues

Buffers & Barriers	Field buffers or strips made comprising of hedges and/or trees assist as wind breaks to reduce soil erosion, a beneficial insect habitat, an insect trap habitat or as a buffer to protect a field from other physical occurrences.
Ensure Clean Water Supply	Isolate an independent water source that will be free from contamination. The area should also serve as a wildlife habitat.
Bio-Diversity	Ensure there is adequate area for bio-diversity (flora and fauna) to establish and settle.
Bird and Bat Habitats	Ensure farmscape will attract birds and bats for insect control.
Soil Ecology	Utilise the practices of intercropping, mixed crops, crop rotation, cover crops, composting and mulching to enrich soil fertility.
Land Cover	Ensure all land is covered to prevent erosion and maintain soil health.

Planning and Site Selection

Developing an organic farm requires more thought about the management and implementation process than conventional farming would require. Substantial knowledge experience and wisdom is needed to understand and make intervention decisions to manipulate the complex relationships within the farm eco-system, without the option to use synthetic fertilizers and pesticides, as would be the case in conventional farming. Further, general theories and farming techniques must be adapted to the specific climate, soil, geography and terrain and social systems existing at the farm site [183]. These constraints determine how sustainable and viable a specific site can be, with the possible allowable set of farm practices that can be utilized on that farm [184].

An organic implementation and management plan must be carefully devised first to examine viability, around the following issues;

1. the management of soils,
2. biodiversity,
3. weed, pest and disease management,
4. water and irrigation management, and
5. contamination risk.

The planning process requires an understanding of the organic certification standards that will be applied to the farm under each category of the standards. Each standard criterion must be considered against available climate, soil, terrain, surrounding hinterland and eco-system, history of land use, labour skill levels and availability and the level of existing knowledge to assess whether the land has the potential to satisfy all requirements.

Climate constrains the types of crops that can be successfully cultivated. Crops should be matched against the climatic parameters of the site. Climate also determines the growth rate and types of pests and weeds, soil moisture evaporation levels and thus heavily influences the methods and practices that will be utilized.

Organic farming should be primary concerned with soil health. The soil is the basic platform from which all activities will have their base, so soil condition is central to both productivity and sustainability. Soil characteristics will determine what crops can grow and how well, what farming methods and practices will be most effective and how mulches and composts should be used within the farming system. Assessing the site soil characteristics is critical to any site selection.

Soils can be classified according to their relative proportions of silt, sand and clay. Component percentages of the soil can be checked against *'The Soil Triangle'*" [185] (see Figure 10.13.) to determine the soil type. For example, a soil with 30% clay, 40% sand and 30% silt, will be a clay loam. The individual soil components can be determined by particle size in each class, where sand particles are between 0.05-2.0mm, silt 0.002-0.05mm and clay less than 0.0002 mm in size. Experienced farmers can determine this through rubbing the soil between their thumb and fingers [186]. Clays will feel sticky and slippery when wet and hard when dry. Sandy soils are loose and grainy and silts are very fine.

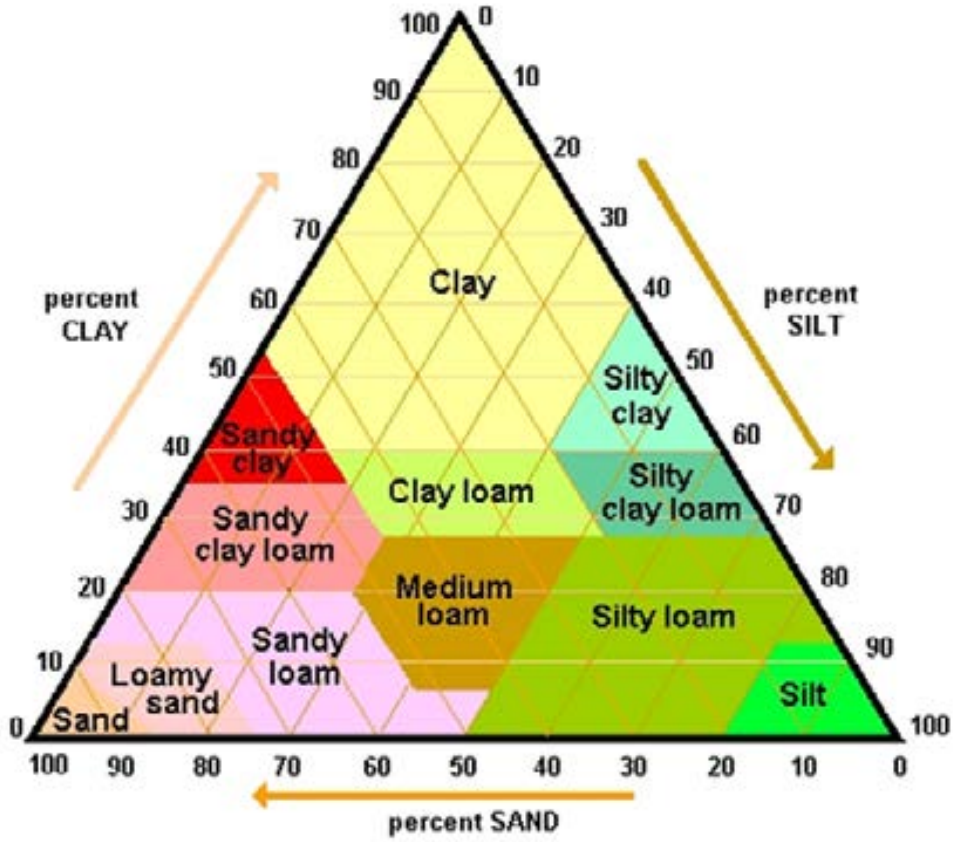

Figure 10.13. The Soil Triangle (used with permission of Idaho OnePlan)

Ideally, a selected site should be some distance from conventional farms and populated areas. This will help prevent contamination from fertilizer or pesticide spray drift, weed infestations, waterway toxins, air and other pollutants. If possible the site should adjoin a forest reserve or jungle area, so the farm eco-system can naturally extend into those areas. This will encourage existing biodiversity onto the farm. If proximity to reserves is not possible, the use of natural and artificial buffers will be important. Live barriers can be utilized to increase biodiversity and protect the farm from pests and contaminants.

If an existing conventional farm is being taken over or converted, farm history should be evaluated to determine the residual effects of past activities on the soil and water reserves. Farm topography should be evaluated for erosion potential and heavy metal and toxin

contaminant. The water supply should be evaluated for independence and cleanliness. If possible, streams with no upstream contaminant sources are best. Local regulations will stipulate whether sub-terrain water is allowed. If so, this must also be evaluated for contaminants. Infrastructure and the farm eco-system should be evaluated for its recycling capacity, *i.e., what is needed to carry out mulching and composting activities on the farm and are they available?*

Labour is another very important issue for an organic farm. Organic farming traditionally utilizes more labour than a conventional farm for weed control, compost making and other

crop protection measures. Will there be enough available labour in the area to cater for farm needs, or can labour saving devices like weeders be developed? As organic farming requires specific skills, education and skill level will be another consideration. Implementation of an organic system will require competent workers who understand the principals of what they are instructed to do. Will workers accept new methods that may be different from the traditional farming methods they have been used to? This issue cannot be underestimated in its importance for successful implementation and conversion of the farm. It may require very persuasive leadership skills to convince workers of the importance and meaning of their work.

Knowledge and experience are two critical issues in the implementation of a sustainable farming system. Thinking conceptually is one thing, but applying the concepts on the farm is another. Good organic farming practices develop through trial and error and experience. Farming on the ground is about *theory in action-finding ways to adapt what is espoused in theory.* Theory brings understanding and perhaps knowledge, but practice brings wisdom. The process of turning understanding and knowledge into wisdom, *i.e., successfully farming organically, will be much easier if there is already a group of organic farmers in the region and the local agricultural authorities and education institutions conducting courses and extension*.

Certification

The organic certification process involves a third party (organic certifying agent) to evaluate a farm and its corresponding processes to determine whether they conform to an established set of operating guidelines, known as organic standards. A farm will only be certified organic after it has gone through a thorough audit by a certification agency. There are many organic certification systems around the World [187]. Some are government agencies, while some are private independent agencies regulated by the International Organic Accreditation Service (IOAS). Some certification systems are more widely accepted than others internationally. However standards between Australia, EU, US and the CODEX Almentarius are comparable in all major aspects [188]. Standards are regularly reviewed and changed to reflect evolving thoughts and philosophies [189]. Domestic certification schemes in South-East Asia still need to be developed further before they are accepted in the US and EU markets [190]. While fees for actual certification are not expensive, travel and accommodation costs for experts to undertake the certification audits are.

Certification standards will include [191];

- Organic Practices
    - soil fertility and management
    - Organic matter, humus and compost
    - Crop rotation policy
    - Water management

    - Irrigation management
- Landscape and Environment
    - Environmental factors
    - Social justice policy
- Pest and Weeds
    - Pest management
    - The use of pest controls
    - Weed management
- Precautions and Other Requirements
    - Residues and possible contamination
    - Windbreaks and buffer zones
- Leasing of land
    - Requirements
    - Transfer of certification
- Processing
    - On farm processing
    - Off farm processing
- Transport and handling
- Storage and warehousing
- Use of Organic Logo
- Seeds and Propagation Methods
    - General
    - Seedling production, nursery and greenhouse production
- Record Keeping

It is important to find a suitable certifier that covers the local region, so that travel costs are not exorbitant and the certification is widely recognized. Before applying for organic certification, it is important to determine whether the farm can comply with the organic standards. For example, an adjoining property contaminating the farm would prevent certification. Organic certifiers will have a checklist similar to the USDA/National Organic Program [192].

Integrity and Record Keeping

The integrity of the organic farm is the sum of the farm design, methods and practices put into place, which is reflected in certification. Record keeping allows the trace back of inputs, raw materials, practices and yields in accordance with risk management protocols. This documentation is important in maintaining systems integrity and necessary to maintain

certification.

Organic Farming in the Asia-Pacific Region

With the rapid growth of organic markets in the United States and the European Union, the situation in the Asia-Pacific region is much more mixed. Like their Western counterparts, middle to high income consumers in South-East Asia share health and lifestyle aspirations and are becoming more interested in organic products. Nowhere more than China can this be seen with a 30% annual market growth, mainly in the Eastern part of the country in 2005 [193]. Within the ASEAN region, markets in Thailand, Philippines and Indonesia are growing steadily, with slower growth in Singapore and Malaysia. This growth can be seen in the organic produce sections in regional hypermarkets and the development of specialized organic shops in major cities. Also organic products like cosmetics are beginning to trickle into the region. In Australia, the domestic market is still growing steadily for organic produce and 50% of domestic production is exported [190]. New Zealand's growth is much more dramatic with an increase of 20% each year [194]. International and local organic cosmetic brands are being launched in both markets.

Australia has the largest land area allocated to organic farming because of organic grazing [190]. A small group of organic essential oil producers of lavender and other herb oils exist throughout the country [195]. In New Zealand approximately 45,000 Ha. was under cultivation with approximately 1000 farmers in 2005 [190]. After a slow beginning, certified[1] organic farming in South-East Asia is beginning to grow. Growing export opportunities, local consumer interest, government support and the availability of recognized organic certification agencies now domiciled within the region has quickened growth in the last couple of years, particularly in Thailand, Indonesia and Vietnam. The number of certified organic farms and acreage in the Asia-Pacific region is shown in Table 10.13.

Table 10.13. Land and Number of Farms Under Certified Organic Cultivation [196]

Country	Land use (Ha.)	No. of Certified Farms	Average Farm Size (Ha.)	% Total Farm use	Year
Australia	12,126,633	1,832	6619	2.71%	2004
China	3,466,570	1,560	2,222	0.60%	2004
Fiji	200	10	20	0.04%	2004
Indonesia	52,882	45,000	1.175	0.12%	2004
Japan	29,151	4,539	6.42	0.56%	2004
Korea (South)	28,218	28,951	0.995	1.46%	2005
Laos	60	5	12	-	2005
Malaysia	581	56	10.375	0.006%	2002
New Zealand	45,000	820	54.87	0.26%	2003
Philippines	14,134	34,990	0.40	0.12%	2004
Taiwan	1,092	-		-	2003
Thailand	13,900	2,498		0.175%	2004
Vietnam	6,475	1,022		0.07%	2001

1 A lot of agricultural production is still by traditional means, which has no chemical inputs and is effectively organic, although not certified.

Conclusion

There are a number of positive factors to encourage the adoption and growth of organic farming. These include pressures on farm production costs from the increasing costs of fertilizers and pesticides, greater influence from the environment movement, the perceived market opportunities and the passion and satisfaction that organic farming brings to many people. The rising cost of oil is set to maintain upward pressure on farm input costs and continue to bring attention to the options of organic farming.

There are also a number of forces constraining the growth of organic farming. There is still widespread lack of knowledge about organic farming. Population growth is bringing many to advocate strengthening conventional farming methods to enable adequate food supply for increasing world population [197]. There is still a lack of research being undertaken in developing countries on organic farming, matched by a distinct lack of training and extension. Still in many places, low levels of organic education exist, and in many areas marketing channels don't exist for farmers wishing to send their products to domestic or international markets.

The production of organically certifiable essential oils is still extremely small. Current production is undertaken by small clusters of farmers, putting their interest and passion into producing selected and specialized oils, with equally small markets. Farmers sell their produce online, to farm visitors, to retail outlets in their vicinity and wherever else some sales can be achieved [198].

Many community projects have failed in the past, producing products without a definite market. The Fairtrade movement formed to ensure that farmers receive a fair price for their goods has provided new channels for farmers in marginalized rural areas is growing rapidly [199]. The growing closeness of the Fairtrade movement and organic farming movement is of particular importance to community based production projects [200].

Organic practices are suitable for annual and perennial herbs. Many organic practices can be adapted in a straightforward way. A number of conventional farmers are picking up organic farming practices to add efficiency and save costs on their farms.

It is the volume oils, grass and tree crops that present the challenges to farming organic essential oils. One of the major constraints to the introduction of organic farming could lie in the monocrop production model.

Organic farming is not without its criticisms. According to a number of studies, it is questionable whether biodiversity on an organic farm is necessarily richer than a conventional farm [201]. If so, it would be difficult to argue that organic farms enhance biodiversity any more than well managed conventional farms [202]. Other studies have shown that energy use on organic farms is similar to conventional farms [203] and organic farms also release as much

greenhouse gasses as conventional farms [204]. According to other studies, organic farm costs above conventional costs because of non-chemical weeding costs [205]. Certified organic farm chemicals are not necessarily anymore natural than conventional farm chemicals, as soaps are neutralized with alkaline salts which are not natural. They are not safer as rotenone has been recently associated with Parkinsons disease and *Bt* pesticides with respiratory effects [206]. Finally, current certification procedures do not take into account outside energy usage.

Finally it is important to restate that a large number of essential oils, particularly those produced in developing countries are cultivated organically, even though they are not certified.

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The first line of personal care entrepreneurship

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Now he is taking the easy life as an associate professor at University Malaysia Perlis. Murray spends half his time in Thailand and the other half looking for opportunities in Malaysia. Murray is passionate and deadly earnest about entrepreneurship and believes everybody should have the chance to "have a go".

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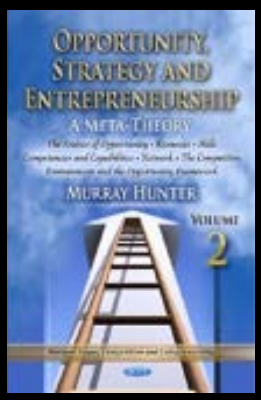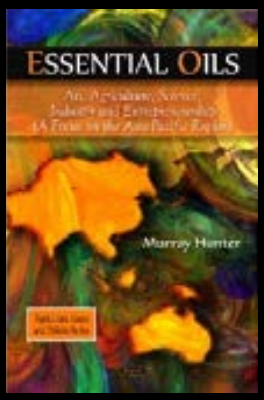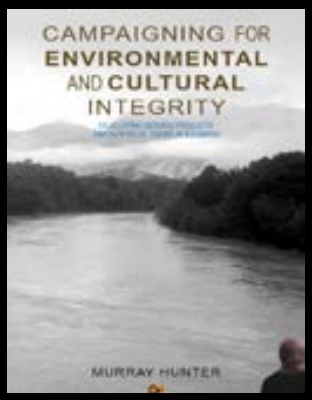
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